The living marine resources of the Southeast Atlantic

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PREPARATION OF THIS PAPER

A major programme of the FAO Fisheries Department is to produce a series of documents reviewing the state of fishery resources of the world.

The present document is included in this series and updates the information previously compiled for this area and published as FAO Fisheries Technical Paper No.178 prepared by Dr. Garth Newman in 1977. Although the present document covers the same area and has a similar structure, it is an original compilation.

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The opinions expressed in this paper are exclusively those of the author. Some comments do not always agree with the official view expressed by the Scientific Advisory Committee of the International Commission for the Southeast Atlantic Fisheries.

ABSTRACT

This study presents the distribution, biological parameters, population dynamics, as well as the degree and methods of exploitation, of the living resources in the area of the International Commission for the Southeast Atlantic Fisheries (ICSEAF), i.e., the area of waters surrounding southern Africa from the rivermouth of the Congo (6°S) in the Atlantic to the northern coast of Mozambique in the Indian Ocean (24°S). Special attention is paid to hake and horse mackerel, which are presently among the most important resources of the area. The effectiveness of the present fishery management system is discussed from a biological point of view, pointing out its failures and drawbacks, in particular for those species whose distribution makes them available for exploitation in international waters. The present and future possibilities of utilization of the resources are evaluated; future trends for management-oriented scientific investigations are outlined.

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1. OUTLINE OF THE ENVIRONMENT

The ICSEAF Convention Area covers the Southeast Atlantic (between latitudes 6° and 50°S and east to the longitude of 20°W) and the Southeast Indian Ocean, west of the parallel 40°E (Fig.1). It thus covers shelf waters of southwest, south, and southeast Africa up to 24°S on the Indian Ocean plus the Tristan de Cunha Archipelago, Gough, St. Helena, Ascension Islands, and the whole underwater South-Atlantic Ridge. To the northwest of Cape Town there is the Vema underwater seamount, which does not reach the sea surface; it is of some importance in the lobster fishery.

The whole Area is divided into Subareas 1, 2, 3, 4, 5, and 8. Subareas 1 and 2, covering the shelves, are further subdivided into statistical divisions.

The coastal states include Angola, Namibia, the Republic of South Africa, and Mozambique (not a member of ICSEAF).

Off northern Angola, the shelf is relatively wide (about 50 km), becoming narrower in the southern part (about 20 km). Off Namibia and the Republic of South Africa, the width of the shelf varies, the widest being on Agulhas Bank. Off the southeastern African coast, the shelf is again very narrow, becoming wider northwards from Maputo. The shelf area in individual statistical divisions is presented in Table 1 (Newman, 1977).

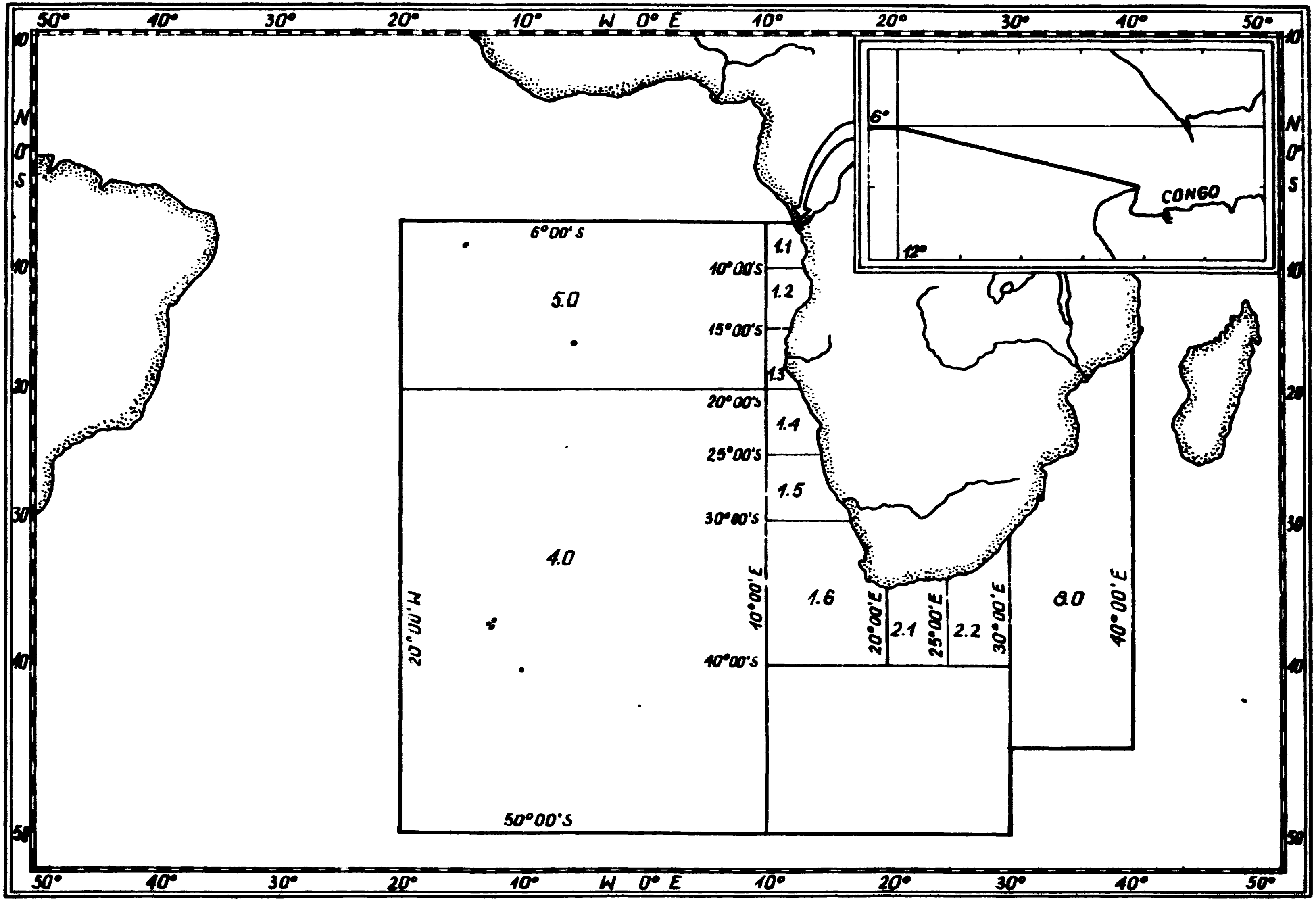
1.2 Hydrology

The main factor influencing oceanographic conditions of the Southeast Atlantic is the Benguela Current. It generally flows northward between Cape Point (35°S) to the Cunene river mouth, extending over 100 nautical miles from the shore. Between Cape Point and 23°S, it flows along the isobaths while north of 23°S it has a tendency to deflect from the shore, making it possible for subtropical waters to move southwards from time to time. Still farther north, it gives rise to the Southern Equatorial Current flowing westwards. The velocities of the Benguela Current are very changeable, usually equalling from 25 to 50 cm/s. It is only a surface current but in places reaches considerable depths of 800-1000 m (Grelowski et al., 1974). The temperature of transported water is lower than that of waters occupying Agulhas Bank and lying farther from the shore. Close to the shore, local countercurrents and eddies are often observed.

The coast of Angola is under the influence of the Angolan Current carrying warm equatorial waters, scanty in mineral salts, southward. It moves over the shelf, reaching the maximum velocity in March - between 9° and 12°S it equals 70 cm/s at the surface and 88 cm/s at a depth of 100 m. The current exhibits the least activity in July, with velocities of 42 cm/s at the surface and 33 cm/s at a depth of 100 m (Dias, 1972). The range of its activity usually does not go beyond the mouth of the Cunene river. However, there are considerable anomalies in the area as was the case in March 1984, when warm waters inflowed as far south as the central coast of Namibia.

Oceanographic conditions of waters surrounding the southeastern part of Africa and on Agulhas Bank are in turn influenced by the Agulhas Current, which is a narrow, fast-flowing stream of warm waters, originating off Mozambique. Its width ranges from 20 to 100 nautical miles at varying distance from the shore, although it generally flows along the isobaths. At a latitude of 30°S and longitude of 30°E, this current flows close to the shore with a velocity of 1-2 m/s. At the latitude of 34°S, the main part of the current starts to deflect from the shore and turns south, or even east, before reaching the meridian 20°E, forming the so-called Return Agulhas Current. The remaining part of the current penetrates into the Atlantic. On the shelf and a part of the slope, the Agulhas Current covers the whole water layer down to the bottom; in the eddies it appears sometimes as deep as 3000 m.

The distribution of surface currents off the coast of southern Africa is presented in Fig.2.



G Statistical area of the International Commission for the Southeast Atlantic Fisheries, divided into subareas and divisions

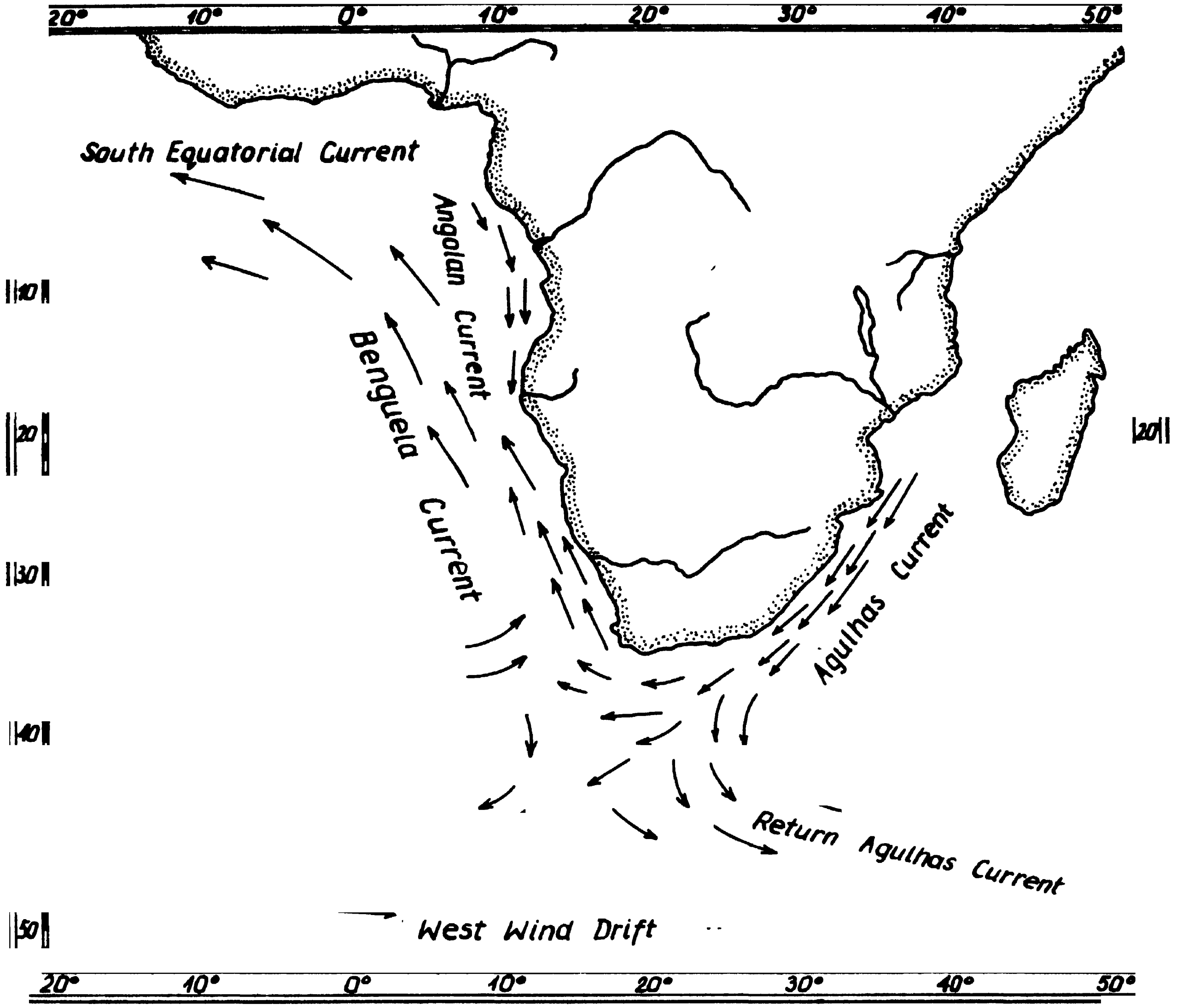


FIG.2 Distribution of surface currents in the ICSEAF Area (after Shanon, 1970 in Grelowski et al., 1974 - slightly modified)

Table 1

Areas of ICSEAF Divisions within 200 and 1 000m depth contours

ICSEAF Divisions	Less than 200m depth	Less than 1 000m depth
1.1	22.3	39.2
1.2	12.2	21.7
1.3	19.5	38.0
1.4	45.1	82.7
1.5	57.9	104.2
1.6	56.4	136.1
2.1	89.3	111.0
2.2	23.4	31.0
8.0	82.1	170.0

Trade winds, blowing always from the south and southeast and the Benguela Current cause exceptionally strong upwelling off the coast of southwestern Africa; on some segments of the shelf it is of a permanent character. South of 29°S, such a stationary upwelling is most active between December and February and least active in July-August. In the area north of 29°S to the Cunene river mouth, the areas and periods of increased activity of upwelling vary, probably due to the changing location of its centres from year to year. Especially strong upwelling is usually observed between August and October, between the mouth of the Orange river (28°30'S) and Lüderitz (26°25'S) and, to a lesser degree, in the Walvis Bay area (Newman, 1977 after Stander, 1964). According to Stetsjuk, 1983, the central area of the stationary upwelling with a long-term mean of cold advection of 9-10°C is located between 24° and 27°S. These values are close to or higher than those noted for the Peruvian upwelling off the coast of South America. The temperature of cold waters transported upward to the surface and the shore north of 29°S equals 12-16°C, while that of waters upwelled as a result of the activity of the Agulhas Current east of Cape Town is much higher, reaching 20°C in summer and 14-18°C in winter.

Upwelling is also observed between 17 and 20°S, usually in May-June, although in some years much earlier, in January-March. The earlier occurrence of upwelling causes anomalies in the distribution of commercial fish concentrations and c.p.u.e. attained, for instance, of horse mackerel (Strogalew, 1983).

North of the Cunene river estuary, the activity of upwelling is low, although in October 1976 - January 1977, an inflow of cold waters onto the continental platform was observed between 9° and 12°S (FAO/PNUD, 1977).

Equally important for environmental conditions and the distribution of fish concentrations (particularly horse mackerel) in the border area between Angola and Namibia are seasonal translocations of the frontal zone of the Benguela Current, where cold waters mix with warm waters from the Angola area. The seasonal translocations of this front are similar to the translocations of the northern hydrological front between Cape Blanc and Cape Verga in northwest Africa where it is caused by the activity of the Canary Current.

1.3 Plankton production

The general index of primary production in the Atlantic Ocean is 0.19 g C/m^2 per day while in the upwelling zones of the Benguela Current - 1.5 g C/m^2 on the average (Cushing, 1969; Moisiejew, 1975) which corresponds to approximately 500 g C/m^2 per annum. Cushing (1969) estimates the level of biological production at individual segments of the coastline in the following way:

Area	Surface area km^2 x 10	Primary production (C)		Production of 3rd trophic level annum, C (wet)	
		ton x 10^6	g/m^2	ton x 10^6	g/m^2
Point Noire - Porto Amboim	35	3	86	0.62	17.7
Baia dos Tigres - Walvis Bay	240	100	417	9.66	40.2
Walvis Bay - Orange River	210	100	476	15.04	72.0
Orange River - Cape Point	144	75	521	8.57	59.5

On the basis of these results, the southeastern coast of Africa is considered a part of the World Ocean with the highest primary production, even higher than off the coast of Peru, Chile, and California (Newman, 1977).

Peak primary production and the resulting peak zooplankton production is correlated with the activity of upwelling; off the coast of Namibia, it occurs between September and March though there are slight changes from year to year.

The primary production is generally much higher in the coastal zone, directly under the influence of upwelling, diminishing with the distance from the coast to the open ocean (Fig.3). On the other hand, the production of zooplankton is lowest near the coast and increases with distance. The highest values off the coast of Namibia are observed 50-60 miles from the shore (Kruger and Boyd, 1984).

It is believed that the observed oxygen deficits in the upwelling area off the coast of Namibia are caused by the decomposition of rich organic matter produced there. The impact of oxygen deficit on marine organisms is not yet fully explained though it is known that it is unfavourable. The results of the "Professor Siedlecki" expedition show that between Cap Frio and Lüderitz (November 1972 - January 1973) the oxygen level below 10% did not have any influence on the nature of horse mackerel concentrations (Grelowski et al., 1974).

The equilibrium in the whole ecosystem may be upset by a sudden intrusion of warm equatorial waters, with drastic negative consequences for living organisms. In March 1984, such an inflow caused a rise in water temperature in the Walvis Bay area (by 6°C), which resulted in a tenfold drop in phytoplankton abundance when compared with March of the previous year and a fivefold drop with respect to February the same year. Besides, death of various organisms was observed, including juvenile horse mackerel, a general drop in the egg production of anchovy and pilchard, as well as changes in the distribution of major commercial species (Boyd and Thomas, 1984; Boyd et al., 1985). These drastic changes resembled the El Niño phenomenon off the coast of Peru in 1972.

2. RESOURCES, THEIR DISTRIBUTION AND CATCHES

2.1 General remarks

The diversity of resources within the ICSEAF Convention Area is considerable and may be seen not only in species composition of ichthyofauna, but also in the abundance of individual populations. This is especially true about the ichthyofauna, both demersal and pelagic, off the coast of Angola and Mozambique.

The composition of the Angolan ichthyofauna (6°-17°S) resembles more that of the northern subtropical zone (10°-20°N) than that of the adjacent Namibia. The stocks of the eastern coast of the Republic of South Africa and Mozambique, subjected to the Indo-Pacific hydrological regime, are quite different as far as the ichthyofauna is concerned.

The total number of species decreases from the Equator southward, and then increases again from Cape Town eastward, as may be seen below:

Area	Number of species	Source
Equator-Walvis Bay	448	Poll, 1959
Walvis Bay-Cape Town	321	Smith, 1950
Cape Town-Port St. Johns (30°E)	637	Smith, 1950
Port St. Johns-Beira (20°S)	1007	Smith, 1950

Higher temperatures of Angolan and Mozambique waters are correlated with an increased number of species but the thermal factor plays a role in the earlier attainment of maturity and thus smaller size of fish. This is usually accompanied by low abundance of quite diversified populations. The opposite situation is observed in the area of activity of the cold Benguela Current, where abundant populations of few species take possession of great areas and are subject to the long-term process of ecological succession (horse mackerel, pilchard, anchovy, hake).

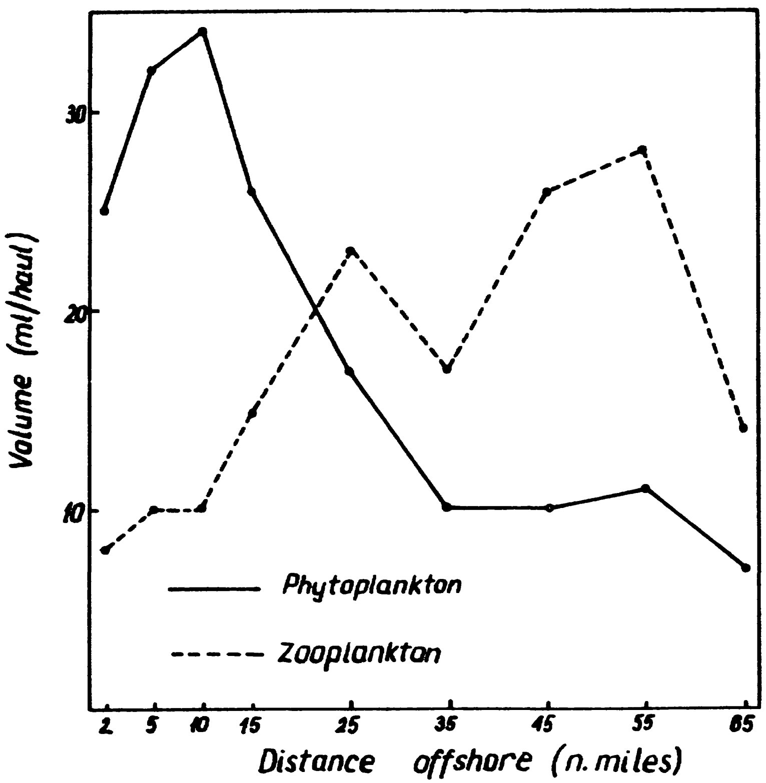


FIG.3 Average of all phyto- and zooplankton volumes plotted against distance off Namibia for the period September 1982 to March 1983 (after Kruger and Boyd, 1984)

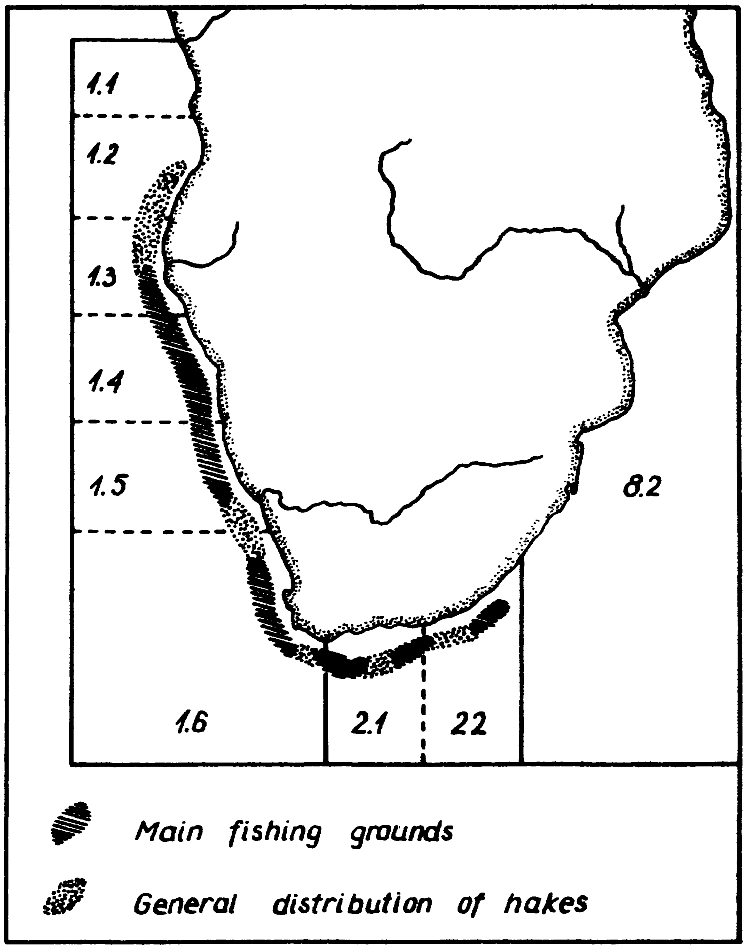


FIG.4 General distribution and main fishing grounds for hake in the ICSEAF Area

From the zoo-geographical point of view, the shelf waters of the ICSEAF Convention Area may be subdivided into four subareas:

(i) The Angolan subarea whose ichthyofauna is under the influence of warm equatorial waters and covering Statistical Divisions 1.1, 1.2 and the northern part of Division 1.3, from 6°S to the Cunene river mouth.

(ii) The Benguela subarea characterized by the highest production on all ecological levels, subjected to the influence of the cold Benguela Current and numerous and very active upwellings. It covers the remaining divisions of Subarea 1 from the Cunene river mouth to Cape Agulhas (20°E).

(iii) The Agulhas subarea, a transitional one, subjected mainly to the influence of the Agulhas Current, where the influences of Indo-Pacific and Atlantic ichthyofauna meet. Statistically it is called Subarea 2, from 20 to 30°E.

(iv) The Mozambique subarea influenced in its entirety by the waters of the Indian Ocean and inhabited by Indo-Pacific ichthyofauna. For statistical purposes it is known as Subarea 8.

In a cross-section made perpendicularly to the coast, the richest fauna is found in the littoral zone. Out of the total of 1253 species occurring between Walvis Bay and Beira (Mozambique), 780 inhabit the littoral zone, 224 demersal species live in the zone of the deeper shelf and its slope, and 96 are abyssal species. The remaining organisms belong to pelagic species (103), bathypelagic (36), and estuarine species (14) (Smith, 1950).

2.1.1 Total catch and species composition

Catch statistics are available since 1960; until 1971, the information concerns the total catch in the whole ICSEAF area by country and species (or their groups); since 1972, additionally subdivided by statistical area and subarea, and by month. Since 1972, fishing effort statistics are also available by area, main species sought, country, fishing gear, tonnage group of vessels and month (ICSEAF Stat.Bull.Nos.2-12; ICSEAF, 1984c).

The total catch in 1960 was 1 148 000 tons and gradually increased to a high of 3 322 000 tons in 1968. In the following years, it remained at a level close to 2 500 000 tons (from 2 133 000 to 3 259 000 tons) to each in recent years (1981-1983) a level of about 2 300 000 tons.

Conclusion on the importance of each division for the fishery may be drawn on the basis of Table 2. The highest catches were recorded in the whole area of activity of the Benguela Current (Divisions 1.3 - 1.6); they were much lower off Angola, and the lowest - off Mozambique.

As is the case in the CECAF area, the largest resources in the ICSEAF area are found off sparsely populated coasts (the Namibia desert - Divisions 1.3, 1.4 and 1.5) while the densely populated coasts of Angola and Mozambique are characterized by small resources (Troadec and Garcia, 1980). The undeveloped fishery of these countries deepens the difficulties connected with the full utilization of both their own resources and the rich resources of the neighbouring countries. An interesting observation concerns a shift in high catches from Division 1.4 in 1972-1978 to Division 1.3 in 1977-1983. This was accompanied by the development of the pilchard population in Division 1.4 and then horse mackerel mainly in Division 1.3, followed by the related development (or decline) of the fishery.

The structure of catches by country in the period 1960-1983 changed with the development of long-distance fleets. In 1960 the catches of the Republic of South Africa and Portugal (the latter fishing off Angola) constituted 99% of all catches equalling 1 148 000 tons; after 10 years, when the total catch increased twofold (to 2 480 000 tons in 1970), the share of these two countries dropped to 65%. In the last analysed year (1983), 15 countries participated in the fishery, out of which the coastal states took 1 040 000 tons (45%), the remaining countries 1 260 000 tons (55%).

Table 2

Total catch in ICSEAF Area by Divisions, 1972-1983

Year	Div.1.1.	Div.1.2.	Div.1.3.	Div.1.4.	Div.1.5.	Div.1.6.	Total SBA1 1/	Total SBA2	Total SBA4	Total SBA5	Total SBA8	Total Convention Area 1/
1972	49	187	606	887	225	690	2684	74			12	2877
1973	44	175	466	1171	336	640	2857	103			17	3079
1974	11	5	254	1123	226	553	2643	152			15	2873
1975	24	77	465	781	211	557	2363	147			5	2527
1976	19	126	402	1140	238	635	2560	117	+		7	2724
1977	23	181	858	679	180	572	2531	173	7	1	9	2722
1978	128	255	1166	884	158	541	3137	98	1	3	19	3259
1979	156	174	835	469	176	517	2325	137	1	1	11	2493
1980	112	135	743	359	119	524	1992	108	1	2	3	2133
1981	101	139	808	534	151	497	2244	89	1	1	1	2349
1982	121	160	902	359	163	475	2188	98	1	1	1	2288
1983	104	152	781	512	167	476	2194	99	1		8	2302

rce: ICSEAF Stat.Bulls. 2 - 12 and ICSEAF 1984c

including data reported for Divisions not known

At present, the greatest share in the total catch is taken by the Republic of South Africa and the USSR, followed by Spain, Rumania, Poland and Angola (Table 3).

The Republic of South Africa and the USSR use various kinds of gear (trawl, purse seine, etc.) while the remaining countries specialize either in pelagic trawl operations (Eastern European countries) or use bottom trawls (Spain, Portugal, Israel).

Despite great species diversity of the stocks, the list of commercial fishes is rather short. Among demersal species, hakes clearly predominate, constituting in 1978-1983 from 82 to 84% of bottom catches, irrespective of their size (Table 4). The remaining species are practically found only in the by-catch, and their importance is determined more by their market value than the size of the catch. These are, for example, sole, kingklip, monkfish, dentex, cephalopods, etc.

The situation of pelagic stocks is more complex. Although the only valuable species are horse mackerel, sardinella, pilchard, anchovy, round herring, chub mackerel, snoek, and possibly hairtail, the long-term natural fluctuations in the abundance of their populations are not without impact on the fishery, resulting in serious difficulties with their stock assessment, prognosis, and determination of the proper management methods.

In the total catches made between 1978 and 1983, the dominant species were: sardinella in Divisions 1.1-1.2, horse mackerel in Divisions 1.3-1.4, and pilchard and anchovy in Divisions 1.3-1.6.

In Table 4, showing total pelagic catches made with various gear in all statistical divisions, the catch situation appears stable. The catches remained in the past 5 years at a constant level of 1 600 000-1 700 000 tons. Significant long-term changes in the size of catch of individual species, especially of Namibia, may be observed in the purse seine fishery. This is true about pilchard and horse mackerel, differing in the 15-year period by a magnitude of 100 or more (Table 5). These differences are not so visible in Division 1.6, for the whole multi-species purse seine fishery where the same catch limit was in force for several years (380 000 tons).

Besides the pelagic trawl fishery developed mainly by non-coastal states outside the 13.5-mile belt of area closed to them, the purse seine fishery of the coastal states still continues to play a role in supplying raw material to local land-based fish meal plants. The latter utilizes mainly anchovy, smaller quantities of round herring and lanternfish, as well as horse mackerel, pilchard and chub mackerel, both adult and juvenile, in different proportions.

2.2 Hakes

2.2.1 Geographical distribution

Among the three species of hakes inhabiting the ICSEAF area, i.e., *Merluccius capensis*, *Merluccius paradoxus*, and *Merluccius polli*, only the former two are of major importance to the fishery.

Since these species are of similar appearance, no distinction is made among them in catch statistics. However, their biology, ecology, and above all, abundance, differ considerably.

M. polli is a subtropical species, found mostly off the coast of Angola; it is of the least commercial importance. Its southern-most range of occurrence was observed at 19°23' (Kawahara and Nagai, 1980) at a depth range of 350-450 m. For practical reasons, it is assumed that hakes caught north of 15°S, i.e., in Divisions 1.1 and 1.2, belong to *M. polli*, while those directly south of this parallel, to *M. capensis*. The greatest catches of *M. polli* in Divisions 1.1 and 1.2 were recorded in 1977 and 1978 - 23 000 and 21 000 tons respectively, although in other years, its annual catch has not exceeded

Table 3

Total catch in the ICSEAF Area by country, 1981-1983 (ICSEAF, 1984c)

Country	1981	1982	1983
Angola	123	104	104
Bulgaria	38	50	58
Cuba	-	1	33
GDR	8	31	69
Iraq	1	-	0
Israel	8	6	5
Italy	3	-	0
Japan	36	27	27
Korea	-	1	7
Poland	125	98	114
Portugal	16	13	18
Rumania	41	82	126
Republic of South Africa	858	822 1/	934
Spain	188	171 1/	176
USSR	905	888	631
Total	2350	2294 1/	2302

1/ The difference of 6 000 tons as compared with Tables 2 and 4 is a result of imprecise statistics from Spain and the Republic of South Africa (ICSEAF Stat.Bull.No.12)

Table 4

Total catches of main species in the ICSEAF Area 1978-1983
(ICSEAF Stat.Bull.Nos.8-12; ICSEAF, 1984c)

Species	1978	1979	1980	1981	1982	1983
Soles	3	3	2	3	5	3
Hakes	575	466	335	364	459	460
Largeeye dentex and angolan dentex	29	21	9	8	14	12
Panga	4	3	2	2	2	2
Kingklip	12	11	11	10	7	9
Anglerfish	12	8	8	19	19	16
Other demersal fishes	63	49	33	37	41	49
Total demersal fishes	698	561	400	443	547	550
Horse mackerel	966	767	691	774	797	749
Sardinellas	241	205	205	160	181	154
Pilchard	148	95	62	99	88	111
Round herring	67	22	14	24	31	70
Anchovy	573	582	526	510	394	427
Snoek	82	32	56	21	32	71
Chub mackerel	202	34	16	61	51	65
Other pelagic fishes	67	58	39	48	28	41
/including tunalike fishes/	/10/	/16/	/10/	/12/	/7/	/11/
Total pelagic fishes	2346	1795	1609	1697	1602	1687
Sharks, rays chimeras	18	9	4	7	7	6
Miscellaneous marine fishes	146	90	91	182	115	41
TOTAL FISHES	3198	2441	2101	2325	2271	2286
CRUSTACEANS	13	11	10	8	6	7
CEPHALOPODS	11	12	7	11	10	10
OTHER MOLLUSCA	1	1	1	1	1	1
SEAWEEDS	26	14	11	-	-	-
ALL SPECIES	3259	2493	2133	2349	2288	2302

Table 5

Catch and main species composition of purse seine fishery in ICSEAF Area, 1950-1983

Year	Angolan coast 1/ 1.1 + 1.2 + 1.3(North part)				Namibian coast, 1.3(Southern part) + 1.4 + 1.5 2/							South African coast 1.6 + 2.1 + 2.2 3/						
	T.Traceae + T.trachurus	Sardinella spp.	Scomber colias	Sardinops ocellata	Trachurus trachurus	Sardinella aurita	Sardinops ocellata	Etrumeus micropus	Engraulis sp.	Lantern fish	Other	Trachurus trachurus	Sardinops ocellata	Etrumeus micropus	Engraulis sp.	Scomber colias	Lantern fish	Total
1950-1955							190					89	117					
1956-1960	89	55					248					54	191	0		25		
1961-1965	106	57					540					42	333	2	153	35		465
1966	183	54			0		801		3			26	118	15	144	54		357
1967	166	45					1 011		22			9	68	32	271	128		508
1968	128	79					1 388		161			1	108	30	138	91	0	369
1969	104	156			0		1 171	2	226			27	56	23	149	92	5	352
1970	164	67			1		528	0	189		1	8	62	24	169	78	18	359
1971	139	86			140		339	2	210		3	2	88	22	157	54	2	325
1972	171	142		73	22		368		137		2	1	104	21	236	57	15	434
1973	175	116		23	12		406		296		5	2	69	29	251	59	42	451
1974				10			559		249		3	3	16	1	350	31	0	401
1975				7	14		560		189		12	2	89	24	224	69	0	407
1976	32	21	1	-			452		88		31	0	176	12	218	1	0	408
1977	39	73	1	7			200		133		82	2	58	35	236	21	6	357
1978	66	231	0	0	9		46		355		9	4	97	67	210	2	1	381
1979	74	161	1	1	32		34		277		32	4	53	21	291	3	9	381
1980	65	196	0		39		11		190		40	0	50	14	316	0	0	381
1981	76	154	0	0	4		52	0	199			6	46	24	292	0	10	379
1982	67	165	0	67	67		51	1	84		0	1	35	31	307	3	1	377
1983	78	148	0	100	106	1	44	1	184	0	2	1	61	69	240	4	2	377

1/ After Newman 1977, Stat. Bulls No. 6-12, ICSEAF, 1984c.

2/ After Newman 1977, Thomas 1984, Le Clus 1984, Stat. Bull. No. 12, ICSEAF 1984c.

3/ After Armstrong *et al.*, 1984.

5 000 - 10 000 tons. Due to the small size of these fish, this species has not been the object of particular interest in the fishery, even on the more productive fishing grounds. In waters with depths 130-300 m, its length does not exceed 25 cm. In the area between 9 and 12°S, it is slightly larger, with modal values in the order of 42-44 cm at depths exceeding 300 m and 54-55 cm at depths of 450-500 m (Sato and Mito, 1981); however, c.p.u.e. attained decreases with depth. The area between 9 and 12°S is the centre of its occurrence, according to the available data.

The information supplied by the expedition of the Cuban research vessel "Isla de la Juventud" (FAO/PNUD, 1977) shows that in the area mentioned above, in the depth range of 250-410 m, the share of hake in total catches fluctuated from 60% to 95%; the c.p.u.e. was about 1 ton per haul. In bottom catches of Soviet vessels (tonnage group of 150-500 GRT and 500-1000 GRT), in 1979-1980, the share of hake in total catches made in Divisions 1.1 and 1.2 did not exceed 1% (ICSEAF Stat.Bull.Nos. 9 and 10).

Because of the lack of sufficient biological and catch data, the stock of M. polli has not been estimated so far. However, on the basis of the suggestions of Newman (1977) and maximum catches, it may be assumed that the potential annual catch does not exceed 20 000 tons and the stock is being exploited to a small degree.

M. capensis and M. paradoxus. The northern-most geographical distribution range of Cape hake (M. capensis) has not been determined. However, its concentrations have been observed as far north as the northern boundary of Division 1.3 (15°S) and in all ICSEAF coastal divisions to the south of it, including Agulhas Bank, where its eastern-most boundary of occurrence is found.

Deep-sea hake (M. paradoxus) occurs beginning at 18°S in deeper water (450-700 m) - beginning at 22°26'S and farther south, in Divisions 1.5, 2.1, and 2.2 also at smaller depth. The eastern boundary for both these species runs on Agulhas Bank, along the meridian 25°32'E (Kawahara and Nagai, 1980). In practice, with the exception of Division 1.3, the areas of distribution of these species overlap.

2.2.2 Vertical distribution

Essential for stock estimation are the differences in the distribution of hake species by depth zones. The information concerning the abundance ratio of both species depending on the depth and area of capture is contained in the results of the analysis of species composition in the hauls, made on board Polish research and commercial vessels in the years 1972-1976, as presented in Table 6 (Chłapowski, 1978).

The information given above was confirmed by later observations of Sato and Mito (1981) and MacPherson and Roël (1984). The latter say that the total abundance ratio of M. capensis and M. paradoxus off the Namibian coast (23°-29°S) at a depth range of 50-500 m in July 1983 was like 2.5 : 1 respectively.

At the same time, each of these species exhibits different vertical distribution, depending on the length and age of fish. With growth, fish migrate to greater depths. That is why the species composition of catches and, within each species, the length frequency, changes with a change in latitude and the depth of capture.

Down to a depth of 200 m, young Cape hake with a length up to 30 cm predominates while deep-sea hake is practically absent from this depth zone. In slightly deeper waters (200-400 m), commercial-sized Cape hake (30-60 cm) begins to predominate. Their length increases with depth; below a depth of 400 m, specimens with a length over 40 cm occur (usually up to 70-80 cm), which is accompanied by a drop in their abundance.

Young deep-sea hake (up to 30 cm in length) occurs at 27°S and farther south, beginning with depths of 200-300 m. Although its presence has been noted already at 23°S and even at 18°S, this refers to depths below 300 m and 450 m respectively. With an increase in depth, the length range of fish widens, but fish below 30 cm in length tend to disappear. At depths of 450-600 m, fish with lengths of 40-70 cm and at greater depths (600-700 m) specimens 60-80 cm in length predominate (Sato and Mito, 1981; MacPherson et al., 1981; MacPherson and Roël, 1984; Morski Instytut Rybacki, 1973).

Table 6

Percentage of Merluccius capensis and Merluccius paradoxus in Polish hake catches according to fishing depth and Division in Namibian waters

Division	Fishing depth				Both depth combined	Zones
	above 350 m		below 350 m			
	M.cap.	M.par.	M.cap.	M.par.	M.cap.	M.par.
Cunene	100.0		100.0		100.0	
Cape Cross	99.6	0.4	87.4	12.6	99.0	1.0
Orange River	87.3	12.7	38.4	61.6	75.6	24.4
Cape of Good Hope	37.9	62.1	0.0	100.0	3.7	96.3
West Agulhas	32.4	67.6	9.9	90.1	17.3	82.7
East Agulhas	64.9	35.1	3.5	96.5	3.9	96.1

Table 7

Catches of hake in ICSEAF Area, 1955-1983

, 000 tons

Year	1.1.+1.2	1.3+1.4[1/]	1.5	1.6	2.1+2.2	Total[2/]
1955	n.a	n.a	n.a	115	n.a	n.a
1956	"	"	"	118	"	"
1957	"	"	"	126	"	"
1958	"	"	"	131	"	"
1959	"	"	"	146	"	"
1960	"	"	"	160	"	"
1961	"	"	"	149	"	"
1962	"	"	"	148	"	"
1963	"	"	"	170	"	"
1964	"	"	"	162	"	"
1965	"	" 94	100	203	"	397
1966	"	212	122	195	"	529
1967	"	195	199	177	17	588
1968	"	383	248	144	31	806
1969	"	321	206	165	42	734
1970	"	403	225	143	28	799
1971	"	366	230	202	35	833
1972	11	606	214	244	51	1126
1973	5	378	290	158	77	908
1974		319	196	123	101	739
1975	5	309	179	90	74	657
1976		370	210	143	58	781
1977	23	278	158	98	40	600
1978	21	289	124	102	43	575
1979	6	172	130	90	54	466
1980	3	103	70	102	48	335
1981	5	101	116	100	37	364
1982	2	194	132	87	47	459
1983	0	222	123	74	41	460

Source: ICSEAF 1985a, ICSEAF 1984c, and ICSEAF Stat.Bulls. No.7-12
n.a. Not available, probably very small

1/ Including M. polli reported by USSR in 1977-1983
2/ Including catches in unspecified Divisions not known in 1977-1983

The maximum of vertical occurrence of Cape hake is at a depth of about 500 m; for deep-sea hake, it is about 800 m. Optimum depth ranges for fishing operations depend on the area and equal 250-400 m for Cape hake and 300-600 m for deep-sea hake. Division 2.2 seems to be the exception to this rule; in January 1973, the largest concentrations of deep-sea hake were observed within the range of 350-400 m as well as 550-800 m (Morski Instytut Rybacki, 1974).

Hakes occur in scattered concentrations close to the bottom or directly above it. These concentrations may sometimes cover considerable areas. During the spawning period they may be quite dense. Hakes undertake characteristic vertical migrations in a diurnal cycle. At night, some fish move upwards, forming scattering layers of considerable thickness; during the day they return to the near-bottom zone. In shallow waters (down to a depth of 250 m) this vertical shift of concentrations is usually less than 20 m, in deeper waters (down to 500 m) they may migrate 100 m and more from the bottom (Morski Instytut Rybacki, 1974).

Horizontal migrations of hakes are not well known although it is obvious that they undertake seasonal movements, which depend on environmental changes. For instance, cases are known when hakes disappear from areas characterized by oxygen deficiency or large amounts of hydromedusae. It was also found that the most prominent concentrations of hake occur in the areas where the horizontal thermal gradient in the near-bottom layer is equal or higher than 0.3-0.4°C per 10 NM (Morski Instytut Rybacki, 1973).

2.2.3 Stock separation

As can be seen from the above the spatial distribution of different species of hake is rather well known; however, the question of separation of various stocks within one species is still open to discussion. At present electroforesis method is used to solve this problem, but so far with no positive results.

Among a number of existing hypotheses, the most convincing states that there are two separate stocks of Cape hake. One of them inhabits Divisions 1.3-1.4-1.5, the other exists around the Cape of Good Hope and on Agulhas Bank (Divisions 1.6-2.1-2.2) and it is possible that specimens from both stocks intermingle at the boundary of Divisions 1.5 and 1.6 (Fig.4). According to the observations of O'Toole (1976), 92% of hake larvae were located during the spawning period 50-100 km off the coast of Namibia, between 22° and 24°S. The location of the spawning ground in the centre of distribution of M. capensis indicates that the existence of a boundary between the two supposedly different stocks on the parallel 25°S is very unlikely. Porebski (1976) also distinguished two areas, with greater abundance of hake eggs and larvae: one between 23° and 28°S, and the other around the Cape of Good Hope.

The separation into four two-species stocks used so far by ICSEAF for evaluation purposes (separately for Divisions 1.3 + 1.4, 1.5, 1.6, and Subarea 2) does not seem to be the best solution, at least with respect to Divisions 1.3 + 1.4 and Division 1.5. Besides the reservations mentioned above, it should be added that the parallel 25°S, separating these areas, runs through the middle of the fishing ground stretching from 23° to 28°S. The results of hydroacoustic stock estimates (Eliminowicz, 1974) confirm the opinion about the uninterrupted occurrence of hakes belonging to one stock from 18° to 28°S, and the other from 33°S southwards along the southern coast of Africa to 26°E.

Even when we assume that at the sites of hake concentrations the fishing effort expended near the parallel 25°S is truly reflected in catch statistics (which in practice cannot be too precise), natural, timely migrations of the stock to the north or south of the parallel 25°S may raise substantiated fears that potential catches are overestimated in one area and underestimated in another.

It is generally assumed that deep-sea hake found in Divisions 1.5 and 1.6 belong to one stock (ICSEAF, 1976). If this is so, the hypothesis concerning the probable existence of separate stocks at the perimeter of its geographical distribution also seems rather unlikely.

Thus, from an ecological point of view, in the ICSEAF Area south of 15°S, there would be three stocks within the two species: two belonging to *M. capensis* and one identified with *M. paradoxus*.

On the other hand, growth parameters of the two species are very similar, although within each of them females exhibit much faster growth than males. This similarity justifies the treatment of the populations of the two species in individual divisions as one stock (Botha, 1971).

Furthermore, the separate treatment of hakes in Divisions 1.3 + 1.4 and Division 1.5 is dictated by practical reasons since the composition of ichthyofauna of both divisions has a substantial influence on the character of the fishery, and above all, on fishing tactics and methods. In Divisions 1.3 + 1.4, fishing operations may be directed at either horse mackerel or hake (the tactics of the Soviet fleet); in Division 1.5 the predominating and sought after species is only hake (the tactics of the Spanish fleet). The different character of the fishery, and thus the different nature of initial statistical data, explains the separate estimations of the four stocks made so far.

2.2.4 Basic stock parameters

The age and growth rate fluctuate within a wide range of values due to the different estimates by various experts. This is a result of different interpretations of rings on the otoliths of hake and the arbitrary classification of a given specimen in a certain age group, depending on the date of capture. It may be expected, however, that as a result of permanent consultations among national ICSEAF experts and several studies dealing with the subject, including a publication of a special guide, significant progress will be made in age and species composition determination of catches (ICSEAF 1980a; ICSEAF, 1983a; Morales and Sanchez, 1980; Wysokiński, 1982; Wysokiński and Chłapowski, 1979; Botha, 1971).

Among several estimates (Kono, 1978), the growth parameters given by Botha (1970) seem to be the closest to reality: L_{∞}=115.7 cm, K=0,13, t_o=0.4438, W=10748g. The remaining parameters are as follows:

Age of first capture with mesh size of 110 mm t_c = 2 years (Draganik, 1982);

Age of full recruitment t_r = 3 years (Draganik, 1978);

Maximum age t_{λ}= 15 years (Kono, 1978).

The determinations of natural mortality coefficient M, substantially influencing the evaluation of the remaining stock parameters, seem quite controversial. Most authors assume for hake stock estimations the value of M between 0.2 and 0.35. In the previous years most authors have assumed for hake stock estimations the value of M between 0.2 and 0.35.

The use of a number of other methods in later investigations suggests that the level of M is slightly higher than 0.2, approaching 0.3, and depends on the rate of exploitation (Wysokiński, 1977). He found that the value of M is higher in unexploited hake populations (*M. argentinus*, *M. hubbsi*) and lower in those heavily exploited (*M. merluccius*), equalling 0.6–0.8 and 0.2, respectively.

Newman (1977) says that the differences in stock size with M equalling 0.1 and 0.3 equal 40–20%, depending on the level of fishing mortality.

On the other hand, in the light of investigations of cannibalism (Preński, 1980; Lleonart *et al.*, 1983; ICSEAF, 1984), it is obvious that natural mortality is not equally distributed among age-groups and may be considerably higher in young fish. This will depend on the abundance ratio between older (age group 4+) and younger fish.

It is worth noting that cannibalism-induced mortality refers to fish prior to recruitment, which would mean that fully recruited stock (over 3 years of age) would be affected by this factor to a small degree. In this sense, the distribution of natural mortality in fully recruited age groups would be uniform.

2.2.5 Fishery and stock assessment

2.2.5.1 Catch and c.p.u.e. statistics

Hake catches by Division, country and year (1955-1983) are presented in Tables 7 and 8. Up to 1964, catch data were reported by the Republic of South Africa and referred mainly to Divison 1.6, where they fluctuated between 110 000 and 170 000 tons. After 1965, when long-range fleets of several European countries and Japan entered the ICSEAF fishing grounds, catches were increasing systematically, covering the whole area of the occurrence of hake. Between 1965 and 1972, the catches increased from 400 000 to 1 120 000 tons (the latter is the maximum level, never reached again). In the next 8-year period, the catches were decreasing to a low of 335 000 tons in 1980. In 1981, a slight upward trend in catches was observed; in 1983, they reached a level of 460 000 tons.

In fishing operations for hake, a large variety of trawlers is being used; they differ by their capacity (GRT), the horsepower of the main engine (HP), processing equipment, and freezing capacities. The fishing tactics and technique are also diverse. Several modern fleets use (besides the traditional bottom trawl) a universal trawl operating in any water layer, from the near-bottom to the sub-surface one. Considerable progress may be observed as far as the use of hydroacoustic equipment and satellite navigation is concerned.

Since it is necessary to have comparative data, total fishing effort expended in a given division during fishing operations for hake is calculated on the basis of catch results of standard trawlers (or their tonnage group) specializing in bottom fishery for a number of years.

For Divisions 1.3 + 1.4, the longest historical series of c.p.u.e. and fishing effort refers to the Spanish fleet. In order to make the data more probable, catch and effort data of different tonnage groups of the Spanish fleet were converted to tonnage group 7 (1 000 - 1 999 GRT). The following formula has been used (ICSEAF, 1985a):

$$\mathrm{cpue}\ (i,7) = \frac{\dfrac{\mathrm{cpue}\ (i,5)}{\bar{u}\ (5)} \cdot \mathrm{catch}\ (i,5) + \ldots\ldots\ldots + \dfrac{\mathrm{cpue}\ (i,8)}{\bar{u}\ (8)} \cdot \mathrm{catch}\ (i,8)}{\mathrm{catch}\ (i,5) \qquad + \ldots\ldots\ldots + \qquad \mathrm{catch}\ (i,8)}$$

where:

$\bar{u}$ (5) ... $\bar{u}$ (8) = mean values of c.p.u.e. for a given tonnage group of vessels (5 to 8) calculated for the period 1976-1981,

cpue (i,5) .... (i,8) = catch per unit of effort for a given year i and tonnage group (5 to 8)

For Division 1.5 indices of c.p.u.e. of the Spanish fleet, tonnage group 7, and the South African fleet, tonnage group 5, averaged by means of the above method were adopted as standard.

For Division 1.6 and Subarea 2, the South African vessels, tonnage group 5, were assumed as standard.

Thus obtained initial data are presented for each division in the appropriate effort and c.p.u.e. tables.

2.2.5.2 Assessment

Until 1983, the assessment of hake stocks and the current maximum catch in the main four ICSEAF Statistical Divisions was based on the Fox-Gulland general production model and, additionally, on virtual population analysis (VPA) and the estimation of yield per recruit.

Table 8

Catches of hake in ICSEAF Area in 1983 by country and Division

('000 ton)

Country	Div. 1.1 + 1.2	Div. 1.3 + 1.4	Div. 1.5.	Div. 1.6	Div. 2.1 + 2.2	Total
USSR	0.1	140.7				140.8
Spain		48.1	80.6	1.6		130.3
South Africa		1.9	25.2	70.3	40.2	137.6
Rumania		7.3				7.3
Portugal		0.1	14.5			14.6
Poland		0.7				0.7
Republic of Korea	0.0	0.4	0.0			0.4
Japan		0.0	0.0	0.0	1.0	1.0
Israel			2.9	1.7		4.6
Cuba		15.3				15.3
GDR		2.3				2.3
Bulgaria		4.7				4.7
Total	0.1	221.5	123.2	73.6	41.2	459.6

Source: ICSEAF 1984c

Table 9

c.p.u.e. historical series (1965-1984) for hake in Divisions 1.3 + 1.4. For dynamic production models data for 1976-1984 and for general production model whole series were used. (Without *M. polli* reported by the USSR in 1977-1983 in Division 1.3)

Year	Catch ('000 t)	f- Spanish unit (h/f)	c.p.u.e.
1965	93,5	52 500	1.78
1966	212,4	162 500	1.31
1967	195,0	214 000	0.91
1968	382,7	399 000	0.96
1969	320,5	364 000	0.88
1970	402,5	447 000	0.90
1971	365,6	420 000	0.87
1972	606,1	842 000	0.72
1973	377,6	662 456	0.57
1974	318,8	697 333	0.45
1975	309,4	737 000	0.42
1976	369,8	880 476	0.42
1977	277,5	565 173	0.491
1978	258,1	590 618	0.437
1979	172,3	423 342	0.407
1980	90,5	201 111	0.45
1981	92,1	165 946	0.555
1982	176,4	327 282	0.539
1983	215,8	367 632	0.587
1984 1/	198,5	312 106	0.636

1/ Estimated

Source: ICSEAF, 1985a

The general production model based on an historical series of fishing effort and catch per unit effort made it possible to determine the size of catch in the following year at a level of fishing effort corresponding to the maximum current production of the stock (f_{MSY}) and at a lower level, corresponding to better conservation of stock and healthier fishery ($f_{0.1}$). On the other hand, analytical models which supply information about the current degree and distribution of fishing mortality by age groups as well as the size of the biomass made it possible to determine the feasibility of the estimation of parameters resulting from the production model.

Although the parameters obtained by means of the two kinds of models have been generally in agreement since the early 1970's as regards the considerable impact of the fishery on the stock and the symptoms of its reconstruction in 1981-1984, looking back it may be said that they exhibited certain discrepancies, which may not be without influence on exploitation and management decision making. These differences referred in particular to the trends of changes in the size of stock determined on the basis of the VPA and resulting from chronological series of c.p.u.e. data (ICSEAF, 1984b).

The discrepancies revealed became the basis for a series of critical analyses of the hitherto used stock estimation methods, as well as the manner of preparation of initial data for analytical models. The criticism centred on the fact that the production model does not take into account population abundance dynamics while analytical models disregard cannibalism and the differences in the age composition of catches made by several hake fishing countries.

The above-mentioned analytical models cannot be improved at present so that they would take into account the cannibalism factor; what can be done is to introduce corrected initial data. On the other hand, the Fox and Schaefer production models gave birth to a whole new generation of dynamic models. Each of the models presented below has its own advantages but dynamic models determine the situation of the hake stock in a more precise way than the traditional general production model (ICSEAF, 1985a).

As a result, stock assessment in Divisions 1.3 + 1.4 and Division 1.5 are at present (since 1984) made with the help of the following models:

(i) The traditional Fox-Gulland production model with the use of a functional regression.

(ii) The VPA method based on the corrected age composition of catches.

(iii) The Butterworth and Andrew (1984) dynamic production model, which is better in adjusting the expected, chronological series of c.p.u.e. to the series actually observed. A complicated procedure was used here, involving non-linear minimalization and the calculation of variation coefficients for two variants of the Fox and Schaefer models.

(iv) The traditional Gulland-Fox model with an additional dynamizing element in the form of a series of c.p.u.e. for some following years, determined by maximum enthropy and, in the second version, by the harmonic weight method. It is also possible to take into account such parameters as the present age composition of the population here (Babayan et al., 1985).

(v) The dynamic production model which takes into account the inertia factor (Lleonart et al., 1985). This is also an improved Fox and Schaefer model, taking into account the resistance and adaptation of the stocks to the changing level of exploitation (inertia). The use of an inertia coefficient (from 0 to 1) gives a better correlation between the expected data and those based on observations, thus making prognoses of the possible degree of stock exploitation more realistic.

2.2.5.3 Divisions 1.3 + 1.4

For a number of years, from 1968 to 1976, hake catches remained at the same high level of 300 000-400 000 tons. 1972 was an exception - the catch reached a high of 606 000 tons. Beginning with 1978/1979, a sharp drop in catches may be observed; in 1980-1981, they reached a low of ca 90 000 tons (100 000 tons with M. polli). The situation was slightly better in the two following years (1982 and 1983) when 176 000 and 216 000 tons and with M. polli 194 000 tons and 222 000 tons were caught respectively (Tables 7 and 9).

Although, according to statistics from the past few years, hake is caught in the area under discussion by 11 countries, significant catches are made only by the USSR and Spain (Table 8). The Soviet catches equalled 141 000 tons in 1983, those made by Spain 48 000 tons, which together constitutes 85% of the total hake catch.

The fishing tactics employed by the USSR, consisting in frequent changes of the main target species (horse mackerel and hake) was the reason for imprecise determination of fishing effort expended and led to the relinquishing of Soviet statistical data. That is why stock estimation was based on Spanish data, presented in Table 9. For the general production model, a whole series of data was used; in the case of the dynamic production model only data from the years 1976-1984.

It appears from the data presented that a downward trend occurred for catch in the years 1986 - 1980 and for c.p.u.e. from 1973, directly after the highest catch in 1972. The c.p.u.e. remained at the same low level in the years 1976 - 1980 (0.41 - 0.49 t/h). This suggests that the stock has remained at the same low level and that since 1977 a further drop in catch has been a result of a progressively smaller fishing effort (Table 9).

Although it is true that the pressure of the fishery on the stock was smaller in the years 1976-1980 as several fleets had either reduced or abandoned their fishing operations for hake (the FRG, Poland, Bulgaria, Japan) claims that the drop in total catch is solely the result of diminished fishing effort are not supported by facts.

First of all, the fact of fleet withdrawal was a result of lower c.p.u.e. attained, which did not balance the costs suffered. Secondly, the biomass of the stock diminished at that time by 60%, dropping from about 950 000 tons in 1976 to 350 000 tons in 1980, as seen in Fig.5 (ICSEAF, 1985a). Thirdly, the analysis of standardized c.p.u.e., taking into account the results of the Soviet fleet, showed that in this period a significant donward catch trend corresponding to the downward trend in biomass took place (Terré, 1983).

Beginning with 1981, all parameters of the stock indicate that the process of its reconstruction is taking place. This is especially true for the upward trend of recruitment to a hitherto unobserved high, caused by the appearance of a number of strong year classes born in 1980-1982, as may be seen in Fig.6 (ICSEAF, 1985a).

The biomass of the whole stock did not exhibit in recent years such a strong upward trend, although in 1984 it reached, as can be seen from Fig.5, a level of about 750 000 tons.

The estimation of the current allowable catch (for 1985), based on the analytical model (VPA), the traditional general production model, and the dynamic production models at a level of TAC_{MSY} and $TAC_{0.1}$ is presented in Table 10 (ICSEAF, 1985a). The differences in these estimates, depending on the model used are very small, especially at a level of $TAC_{0.1}$. The mean magnitude of the allowable catch for 1985 resulting from the dynamic production models equals 266 000 tons (after rejecting the highest and lowest values), which is almost identical with the figure obtained by means of the traditional model of general production (268 000 tons).

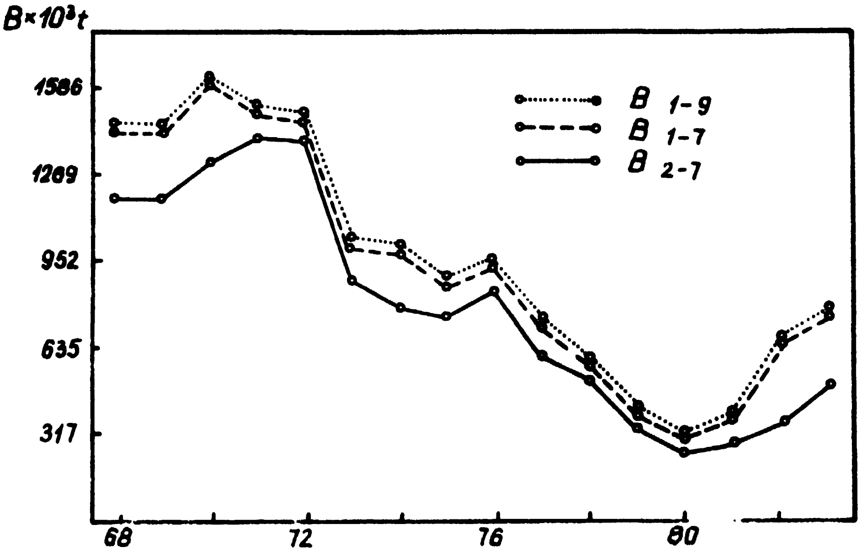


FIG.5 Hake biomass in Divisions 1.3 + 1.4 in 1968-1983 (ICSEAF, 1985a)

B_{1-9} - biomass of age groups 1-9

B_{1-7} - biomass of age groups 1-7

B_{2-7} - biomass of age groups 2-7

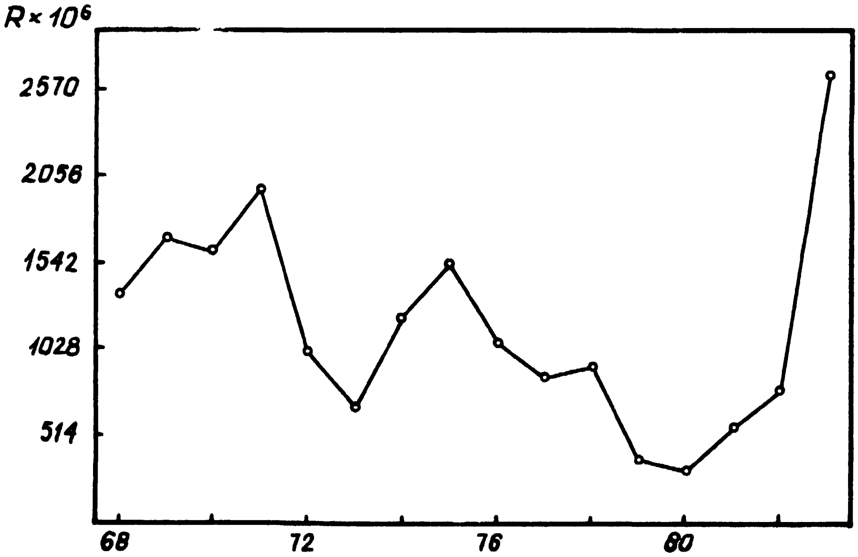


FIG.6 Recruitment trends for hake in Divisions 1.3 + 1.4 in 1968-1983 (ICSEAF, 1985a)

Table 10

Catch level estimates for Cape hakes in Divisions
1.3 + 1.4 + 1.5 (ICSEAF, 1985a)

Method	1.3 + 1.4		1.5	
	TAC_{MSY}	$TAC_{0.1}$	TAC_{MSY}	$TAC_{0.1}$
Gen.Prod.Model	329	268	187	165
Babayan *et.al.*,:				
a/max.entropy	391	305	198	155
b/harmonic weights	353	276	211	165
Butterworth:				
a/ Schaeffer	263	239	175	168
b/ Fox	249 1/	253 1/	162 1/	166 1/
Lleonart *et al.*,				
a/ Schaeffer	298	277	173	164
b/ Fox	309	259	165	146
VPA	280		168	
Mean value 2/	306	266	178	163

1/ This apparent contradiction of MSY and 0.1 values has arisen because the model estimates that the stock has risen above the target level (biomass at $F_{0.1}$ equilibrium) because of low catches in 1983 and 1984. The results are therefore valid.

2/ The mean value is calculated from the results of the dynamic approaches of Babayan *et al.* (1985), Butterworth and Andrew (1984), and Lleonart *et al.* (1985). The procedure adopted was to omit the two extremes and to determine the average of the remaining four figures.

2.2.5.4 Division 1.5

The history of hake stock in Division 1.5 resembles that described for Divisions 1.3 + 1.4. The stock was heavily exploited since 1967; until 1976 the size of catch fluctuated between 180 000 and 250 000 tons, with the exception of 1973, when the greatest catch was observed - 290 000 tons. As was the case with Divisions 1.3 + 1.4, a gradual drop in catches began in 1977, reaching a low of 70 000 tons in 1980. Since 1981, the catches began to rise slightly, remaining at a relatively low level of 120 000 - 130 000 tons (Table 11).

In the 1970's, hake was the object of the fishery of almost all ICSEAF member states; in recent years their number diminished so that now Spain, the Republic of South Africa and Portugal are the main operators (Table 8). In 1983, all these three countries landed 98% of all hake catches. The USSR practically abandoned fishing operations in Division 1.5 while other countries limited their operations to sample hauls, which resulted in the decrease of the exploitation rate of the stock.

Still, as is the case with Divisions 1.3 + 1.4, the reasons for a drastic decline in catches in the years 1977-1980 are not quite clear in the light of data believed by ICSEAF to be representative. According to ICSEAF the stock abundance index - c.p.u.e. from 1974 to 1980 remained at a stable level, which is lower by about 40% than the level in the best years 1969-1973, but it did not exhibit a downward trend which could correspond to the decline in catches (Table 11). Thus, these data would also suggest that the decline in catches was caused primarily by the reduced fishing effort. However, this was not confirmed by a drop in biomass or by the statistics of other countries. For instance, the historical series of Polish c.p.u.e. data exhibited a well-pronounced, sharp downward trend, reflecting closely the situation of biomass and total catch (ICSEAF, 1983c). In the case of the Polish fleet this was the only factor responsible for the decision to halt hake-directed fishery.

It is thus doubtless that the drastic decline in catches in the years 1977-1980 in both Divisions 1.3 + 1.4 and Division 1.5 was caused primarily by the poor and ever worsening state of the stock, and the resulting decrease in the rate of exploitation.

The above remarks suggesting that in the years 1977-1980 the stock was in poor condition, probably due to excessive exploitation, have now lost some of their importance in view of the favourable recent changes.

From 1981 to 1984 upward trends of the biomass and recruitment indicate that the process of stock recovery is taking place, although to a lesser degree than in the case of Divisions 1.3 + 1.4. These tendencies are illustrated in Figs. 7 and 8 (ICSEAF, 1985a).

The estimations of the allowable catch for 1985 were made by the same methods as those for Divisions 1.3 + 1.4; they are presented in Table 10. The calculated mean value of $TAC_{0.1}$ was 163 000 tons from the dynamic models, and 165 000 tons from the traditional general production model. It is a safe level and corresponds to the maximum production of the stock.

2.2.5.5 Division 1.6

Division 1.6 is characterized by the longest documented history of hake landings. Prior to the introduction of high-seas fishing fleets (the early 1960's), fishing operations were conducted mainly by the Republic of South Africa, the catches fluctuating between 120 000 and 160 000 tons. When these fleets commenced fishing, i.e., from 1965 to 1971, the catches increased to 150 000 tons-200 000 tons. Peak catches were recorded in 1971, as was the case with northern divisions (244 000 tons), followed by a sudden decline to a low of 90 000 tons. Catches remained at this low level of 90 000-100 000 tons until 1982; in 1983, the lowest catch of 74 000 tons was recorded.

A representative series of catch, c.p.u.e., and fishing effort for the years 1955-1983 is presented in Table 12. The decline in catches visible since 1973 was accompanied by a drop in c.p.u.e. and an increase in fishing effort. The mean value of c.p.u.e.

Table 11

Catch and fishing effort statistics for Cape hakes in Division 1.5

Year	Total catch (' 000 t)	Pooled c.p.u.e. index	Standarized fishing effort
1965	99,7	210	474,8
1966	122,2	247	494,7
1967	199,4	136	1 466,2
1968	247,7	132	1 876,5
1969	206,2	108	1 909,3
1970	224,7	103	2 181,6
1971	229,7	134	1 714,2
1972	214,0	100	2 140,0
1973	290,3	94	3 088,3
1974	195,5	66	2 962,1
1975	178,7	76	2 351,3
1976	209,7	54	3 883,0
1977	157,7	65	2 426,2
1978	124,2	51	2 435,3
1979	130,0	69	1 884,1
1980	70,1	70	1 001,4
1981	116,4	84	1 385,7
1982	131,8	82	1 607,3
1983	123,3	96	1 284,4
1984	121,4	101	1 202,0

Source: ICSEAF, 1985a

Table 12

Cape hakes in Division 1.6. South African catch and effort statistics, 1955-1983

Year	Catch (' 000 t)	f (d/f)	c.p.u.e.
1955-59	127,3	7 783	16,36
1960-64	157,6	11 179	14,10
1965	203,0	18 755	10,82
1966	195,0	18 344	10,63
1967	176,7	17 652	10,01
1968	143,6	14 346	10,01
1969	165,1	19 153	8,62
1970	142,5	19 710	7,23
1971	202,0	28 491	7,09
1972	243,9	49 776	4,90
1973	157,8	31 751	4,97
1974	123,0	26 452	4,65
1975	89,6	19 227	4,66
1976	143,4	26 804	5,35
1977	97,5	20 145	4,84
1978	101,7	17 237	5,90
1979	90,4	14 747	6,13
1980	101,5	18 422	5,51
1981	99,6	17 143	5,81
1982	86,9	14 804	5,87
1983	73,7	11 352	6,49

Source: ICSEAF, 1985a

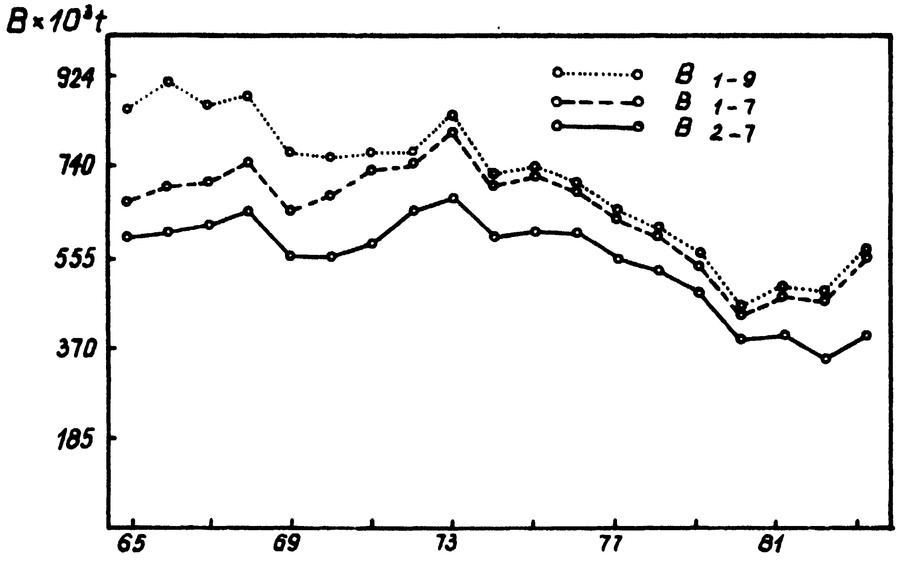


FIG.7 Hake biomass in Division 1.5 in 1968-1983 (ICSEAF, 1985a). Symbols the same as in Fig.5

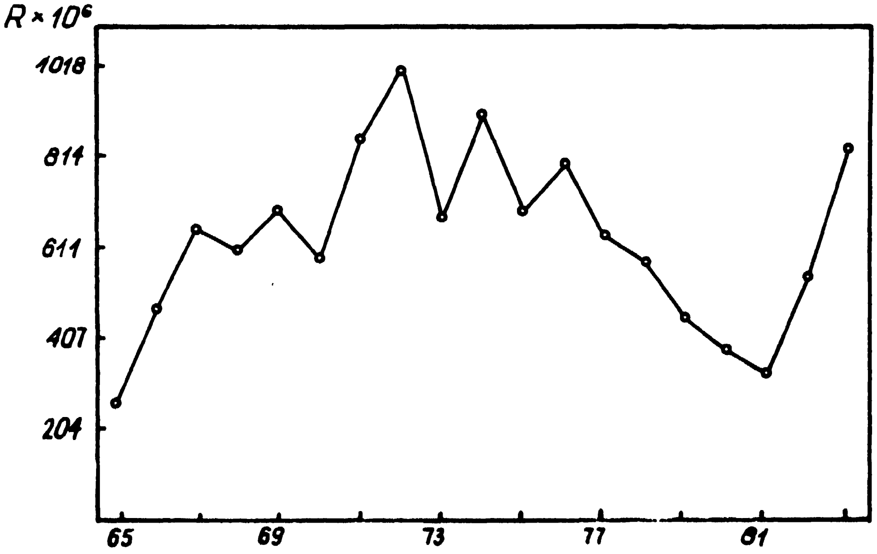


FIG.8 Recruitment trends for hake in Division 1.5 in 1968-1983 (ICSEAF, 1985a)

for the years 1972-1975 was 4.77 t/d, i.e., less by approximately 65% than in 1951-1964, and by 50% less than in 1965-1968. In the years 1980-1983, the slow but systematic reduction of fishing effort was accompanied by a slight increase of c.p.u.e. from 5.5 to 6.5 t/d.

The stock biomass remains in practice on the same low level of about 250 000 tons from the moment of the sharp decline in catches in 1975 until the present day (Fig.9). The recruitment trend, despite slight improvement in 1981 and 1982 (Fig.10), gives no basis for optimistic prognoses as was the case with Divisions 1.3 + 1.4 and Division 1.5.

For the determination of the current fishing possibilities, the traditional general production model and a functional regression were used (Fig.11). As can be seen from the presented data, the maximum allowable catch at a level of f_{MSY} = 113 000 tons falls considerably short of the maximum stock productivity (MSY = 148 000 tons). As in the case of northern divisions, it is recommended that a safe level, equalling for 1985 $f_{0.1}$ = 82 000 tons, be employed (ICSEAF, 1985a).[1]

2.2.5.6 Subarea 2

Catches in Divisions 2.1 and 2.2 have been recorded since 1967, when 17 000 tons of hake were taken. Catches increased systematically from that moment on, reaching a maximum of 101 000 tons in 1974 and then dropping to 40 000 tons in 1977. They remained at a level of 40 000-50 000 tons until 1983 (Table 13).

Outside the period of great catches in 1972-1976 made by the fleets of various countries, the stock was exploited mostly by the fleets of the Republic of South Africa and Japan, the activity of the latter steadily decreasing. In 1983, Japan took only 1 000 tons of hake there (Table 8).

The historical series of c.p.u.e. data for the years 1967-1983 is presented in Table 13.

The general production model used for the stock assessment indicates that the maximum allowable catch (f_{MSY}) and the maximum production of the stock (MSY) remain at the same level of 56 000 tons. The recommended safe level of $f_{0.1}$ for 1985 was 44 000 tons (Fig.12).

In the past 8 years (1976-1983), the biomass level (B_{3+}) indicated that the stock remains at a stabilized level, but lower by about 50% than that in the years of best catches (1972-1974).

What differentiates this area from Divisions 1.3 + 1.4 and 1.5 is that recruitment in recent years (1980-1983) exhibits a marked downward trend. That is why the biomass consists mostly of older specimens (ICSEAF, 1985a). The improvement in the stock condition cannot be thus expected, unless it would be replenished by strong year classes from the northern divisions.

2.2.6 General comments and hake fishery regulatory measures

The maximum sustainable yield (MSY) in the ICSEAF Convention Area remains at a level of 700 000-800 000 tons; if M. polli from Divisions 1.1 and 1.2 is taken into account, 20 000 tons may be added to this figure. According to estimates made in 1983, it is lower by 100 000 tons than the one made in 1976 (Newman, 1977), which is probably due to the longer period of observations of the population with low biomass than the reduced production capabilities of the stock.

In all statistical divisions with the exception of 1.6, the present allowable catch (f_{MSY} 1985) approaches the MSY, which would mean that the stocks have reached or have come close to the maximum production capability (Table 14). Such a favourable situation is the result of a number of factors. It is worth mentioning the following:

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[1] According to recent information, since 1983 South African authorities have employed a more conservative measure by setting a catch quota at 10% below the $f_{0.1}$ (Botha, 1985, personal communication).

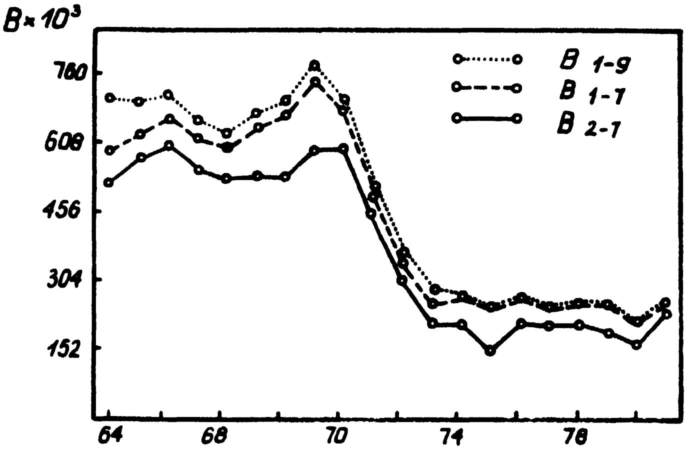

FIG.9 Hake biomass in Division 1.6 in 1968-1983 (ICSEAF, 1985a). Symbols the same as in Fig.5

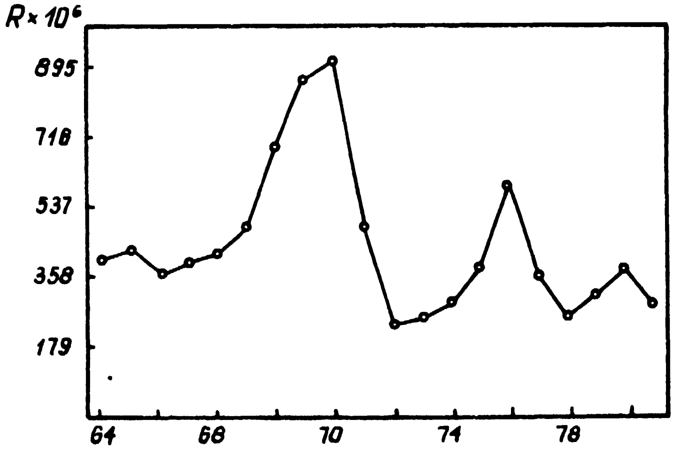

FIG.10 Recruitment trends for hake in Division 1.6 in 1968-1983 (ICSEAF, 1985a)

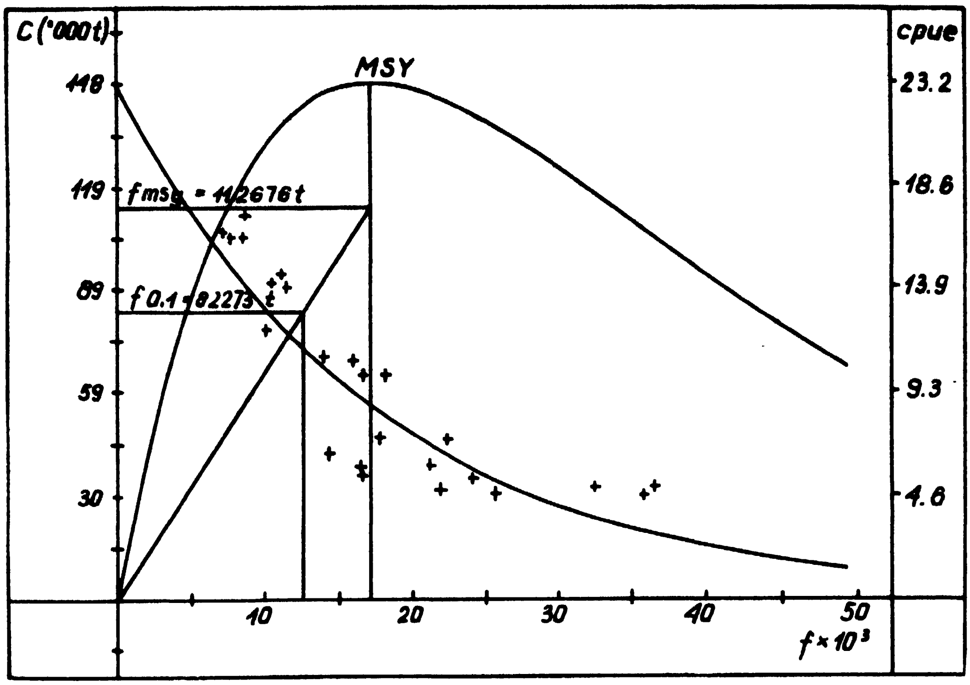

FIG.11 General production model for hake stock in Division 1.6 and c.p.u.e. trend in 1960-1983 (ICSEAF, 1985a)

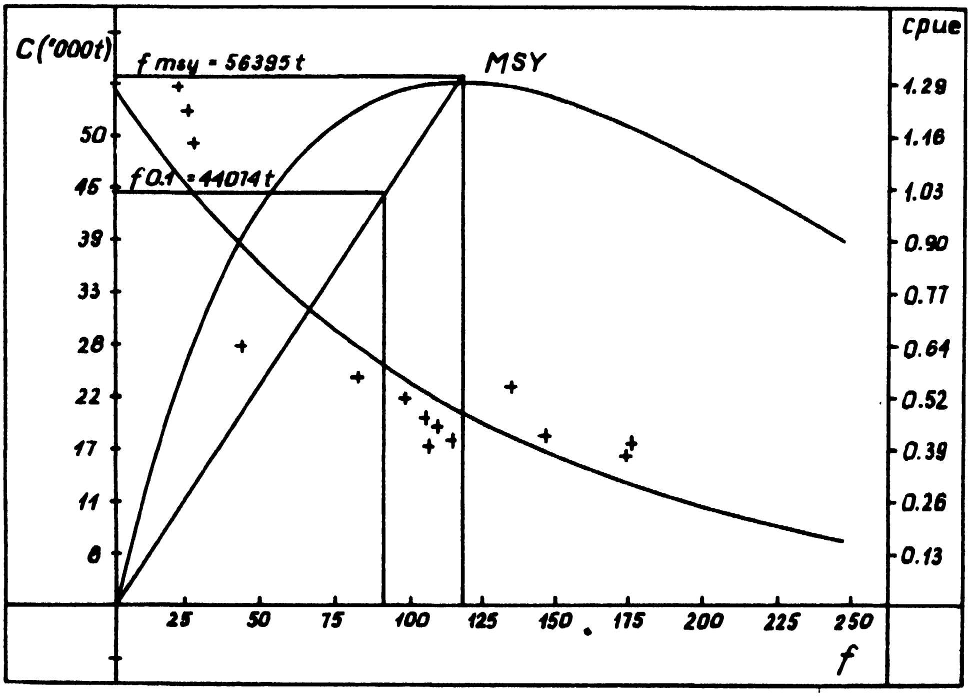

FIG.12 General production model for hake stock in. Division 2.1 + 2.2 and c.p.u.e. trend in 1967-1983 (ICSEAF, 1985a)

Table 13

Cape hakes Divisions 2.1 + 2.2.
Catch and fishing effort statistics, 1967-1983

Year	Catch ('000 t)	f standard	c.p.u.e.
1967	17,34	13 345	1,30
1968	31,37	24 509	1,28
1969	41,70	32 576	1,28
1970	27,80	22 787	1,22
1971	34,50	30 263	1,14
1972	51,40	80 313	0,64
1973	77,40	138 214	0,56
1974	100,90	186 851	0,54
1975	73,80	199 459	0,37
1976	57,70	144 251	0,40
1977	40,47	96 367	0,42
1978	42,76	104 287	0,41
1979	53,83	117 023	0,46
1980	47,57	108 115	0,44
1981	37,43	95 972	0,39
1982	47,26	92 671	0,51
1983	41,17	85 779	0,48

Source: ICSEAF, 1985a

Table 14

Maximum sustainable yield of hake and the estimated total allowable catch for 1985 in the ICSEAF Convention Area (ICSEAF, 1976; ICSEAF, 1983c; ICSEAF, 1985a)

('000 ton)

Division	MSY		TAC - 1985		Catch
	1976	1983	f_{MSY}	$f_{0.1}$	1983
1.3 + 1.4	350	306	306	266	216[1/]
1.5	210	178	178	163	123
1.6	165	150	113	82	74
2.1 + 2.2	70	56	56	44	41
Total	795	690	653	555	454
%		100	95	80	66

[1/] Without *M. polli*

- exceptionally high recruitment in the years 1980-1982, particularly in northern Divisions 1.3 - 1.5;
- catch regulatory measures undertaken in the past;
- the fact that some countries in the past few years have not fulfilled their assigned catch quotas.

It is worth emphasizing that the abundant year classes of 1980-1982 originate from the biomass of the parent stocks, whose level was the lowest in the history of the investigations.

According to the model of Garrod and Jones, recruitment at the level of the maximum mean (1 130 million of fish age 2) should be ensured in Divisions 1.3 + 1.4 when the biomass of fish age 4+ equalled 537 000 tons (Draganik, 1982). Meanwhile, as can be seen from Figs. 5 and 6, the biomass of fish age 2-7 equalling 320 000 tons (and thus smaller by 40% than the above mentioned optimum) gave recruitment at a level of 2 570 million of fish, i.e., over 100% higher than that expected from the optimum biomass of the spawning stock (537 000). Opposite effects may be expected on the same scale; this would considerably increase the requirements concerning the size of the spawning stock.

It is obvious that in the case of the years 1980-1982, the increase in recruitment depended primarily on the favourable environmental conditions (i.e., incidental circumstances) prevailing at that time and not on the size of the spawning stock.

On the other hand, the unexpected growth rate of recruitment in recent years might have been influenced by the population autoregulation, consisting in the reduced cannibalism of the small parent stock with respect to 1- and 2-year old recruits.

The existing considerable fluctuation in the hake population abundance, and especially the downward trends in biomass and catches, observed in the years 1976-1980, unarrested by the regulatory measures introduced so far, point out to the necessity of analysing stock management in the following aspects:

(i) The effect of the use of 110-mm mesh size in hake fishery.

(ii) The effectiveness of the "catch quota" strategy based on the estimation with the help of the general production model.

(iii) The impact of the horse mackerel fishery on the recruitment level of hake.

(iv) The possibility of the implementation of fishing effort limits.

2.2.6.1 Effect of the use of 110-mm mesh size

The introduction in July 1975 of minimum mesh size (110 mm) in the hake fishery was to ensure an increase of the stock by 5-12% after 2-3 years (ICSEAF, 1976a). International monitoring organized by ICSEAF has shown that the required mesh limit has been observed. However, the effect of the introduction of this measure has not manifested itself either in an increase in c.p.u.e. or in an increase of the stock biomass. It is possible that its effect was obscured by a much stronger downward trend of recruitment, and the observed drop in the size of the stock in the years 1976-1980 could have been much deeper if the mesh limit had not been used. Under such conditions, the increase in the mesh size does not automatically lead to increased c.p.u.e. as assumed in the theoretical model (Draganik, 1982).

Besides, the unclear effect of the mesh size increase might have been unfavourably influenced by other factors. For instance, it has been found that the share of small fish in some hauls was often greater than could be expected from the use of larger mesh (ICSEAF, 1974). The regulation concerning the use of Polish-type topside chafers, unsupported by wider investigations, should be revised after finding out to what degree it restricts in practice the escape of fish.

The possibility of using larger mesh size than 110 mm should be analysed. Investigating what conditions are necessary to obtain maximum yield per recruit, Draganik (1982) showed that in Divisions 1.3 + 1.4, age at first capture in hake should increase from two to about three-five (mean four) years, when the rate of exploitation remained at the level achieved then. This could be achieved when the mesh size was increased to 140 mm.

The conceivable introduction of this mesh size would have to be preceded by investigations which would take into account the following factors:

- the optimum ratio of the abundance of fish age 4+ as predators to the abundance of small fish as prey;
- the impact of the protection of smaller fish on sex ratio in parent stock in order to see to what degree this protection would cover more slowly growing males and faster growing females;
- direct and long-term impact of the new mesh size on the stock and the resulting economic and exploitation effects.

It appears from the analyses made so far that further increase of the mesh size will be more profitable when exploitation rate is high (ICSEAF, 1974).

2.2.6.2 Catch quota strategy

The introduction in 1976 of limited catches and national catch quotas for hake did not raise, according to some experts, the desired results and turned out to be an inefficient regulatory measure as far as maintaining the maximum sustainable stock level is concerned (Draganik, 1982).

As can be seen from Table 15, after the introduction of catch quotas, catches dropped systematically, in spite of the permanent reduction of the TAC, which in turn led to the further drop in the TAC. As a result, the TAC in Subarea 1 was determined for 1981 at a level lower by 70% than that for 1976.

The reason for this was, among others, the use of an insufficiently sensitive general production model for the determination of the TAC at a time when the stock was not at an equilibrium, and when recruitment and biomass exhibited downward trends. Dynamic models introduced in 1984 would no doubt be better tools for the determination of the present possibilities of increasing exploitation.

The choice of the Spanish series of c.p.u.e. as the representative data for the whole stock would also have played a role here. As shown in discussing Divisions 1.3 - 1.5, these data did not sufficiently reflect the situation of the stock, especially the biomass trend during the drop in catches in the years 1976-1980. Neither did they conform with c.p.u.e. series of other countries, which - though covering a shorter period and representing small catch - exhibited greater agreement with the trends of other stock parameters.

It would seem useful to take into account in the future, c.p.u.e. data of other countries with the Spanish series as representatives only for Spanish catches. This conclusion is justified primarily by the fact that the Spanish fleet uses different fishing tactics and techniques than other countries, basing their catches on a fraction of the stock consisting of fish in older age groups (Sanchez _et_ _al._, 1984).

It is worth noting that the possible errors in estimations of the allowable catch for hake were corrected in practice by the economic factor, i.e., by the value of catch per unit effort as a function of costs expended. As can be seen from Table 15, as a consequence of overestimating allowable catch in Divisions 1.3 + 1.4 and 1.5 in 1979, and especially in 1980, the catch dropped automatically, and the catch quota was utilized only in 54%. This phenomenon was accompanied by restricting or abandoning fishing operations for hake by a number of countries, for which the low c.p.u.e. turned out to be an economic barrier. As a result, the exploitation rate dropped, enabling the stock to rebuild its potential.

Table 15

TAC and effective catch of hake in the ICSEAF Area, 1976-1985 (ICSEAF, 1984d)

Year	Divisions 1.3 + 1.4 + 1.5 (Namibian Coast only)				Divisions 1.6 + 2.1 + 2.2				Total		
	TAC		Catch		TAC		Catch		TAC	Catch	
	Recommendation by SAC 1/	Regulation	'000 t	%	Recommendation by SAC 1/	Regulation	'000 t	%	Recommendation by SAC	'000 t	%
1976	650		580	89	300	-	201	67	950	781	82
1977	480	536	436	91	150	164	138	92	630	574	91
1978	414	480	382	92	142	148	145	102	556	527	95
1979	360	416	302	84	149	150	144	97	509	446	88
1980	300	320	161	54	112	-	150	134	412	311	75
1981	190	212	208	109	140	-	137	98	330	345	105
1982	352	352	308	88	128	-	134	105	480	442	92
1983	413	413	339	82	128	-	115	90	541	454	84
1984	391	413	320 2/	82	129	-	116 2/	90	520	436	84
1985	429	429			126				555		

1/ TAC for 1976 on the level of MSY
TAC for 1977-1978 on the level of $f_{10\%}$
TAC for 1979-1985 on the level of $f_{0.1}$

2/ Estimated

Despite a number of drawbacks and imperfections, the system of limiting hake catches and assigning national catch quotas is one of the few regulatory measures which may be used in practice on international fishing grounds and should be continued and improved.

2.2.6.3 Impact of horse mackerel fishery on hake stock

Assuming that young year classes of hake occur on horse mackerel fishing grounds within the depth range of 120-250 m, a suspicion arose that the horse mackerel fishery may have a harmful influence on the recruitment level in hake.

In connection with the above, as well as to protect young horse mackerel, a minimum mesh size of 60 mm for trawl horse mackerel fishing was introduced in 1981; in 1982, it was extended for the whole trawl fishery. Besides, in 1981 the permissible share of hake in horse mackerel directed fishery was reduced from 30 to 20%.

Investigations carried out for several years by a number of countries, culminating in a discussion at an ICSEAF session in December 1984 (Torremolinos), showed that this impact after the introduction of the above-mentioned regulatory measures is overestimated and does not require additional measures.

The by-catch of hake in fishing operations for other target species with respect to total hake catches was 9-14% in 1981-1983 in the whole ICSEAF Area. This share was especially high in Soviet catches in Division 1.3, as is illustrated by the following data (in percent of the total hake catch respectively, ICSEAF, 1984).

Area	1.3		1.4		1.5	1.6+2.1+2.2	ICSEAF Area	
Year	USSR	All countries	USSR	All countries	All countries	All countries	USSR	All countries
1981	77	59	51	13	0.1	4.4	6.7	9.4
1982	88	67	16	12	0.1	3.5	10.6	13.9
1983	80	56	0.0	6	0.3	3.0	10.0	13.6

Besides horse mackerel, the target species were sole, chub mackerel, kingklip and squid.

The share of hake by-catch referred to total catches of the USSR in the same period (1981-1983), fluctuated between 3.5 and 17.5% in Division 1.3 and between 3.1 and 12.1% in Division 1.4. These data are probably overestimated since the fishing effort of the Soviet fleet is not accurately separated into target species and some part of it should be in fact included as directed to hake (ICSEAF, 1985a).

More reliable data concerning catch results of the Polish fleet directed solely at horse mackerel in Divisions 1.3 + 1.4 revealed that the share of hake in horse mackerel catches in the years 1980-1984 fluctuated from 0.1 to 2% of total catch, as shown below:

	1980	1981	1982	1983	1984 (Jan./June)
Total catch (tons)	71 643	121 618	98 113	113 832	42 175
Horse mackerel catch (tons)	69 502	118 837	94 677	108 297	41 604
Hake catch (tons)	1 475	1 003	136	726	70
% of hake in total catch	2.0	0.8	0.14	0.6	0.16

The fleets of Bulgaria and the German Democratic Republic also engaged in horse mackerel fishery report a by-catch of hake for 1983 at a level of 4.1 and 3.1%, respectively , with the highest share in December-February (13-15%) and the lowest in June (0.2%) (Kolarov and Prodanov, 1985; Below, 1985).

Taking into account the fact that the length composition of hake in by-catch is diversified (young specimens of up to 30 cm in length may constitute as little as 1-17% of all by-catch - Chłapowski et al., 1982), it is obvious that the impact of the horse mackerel fishery on hake stock is insignificant.

2.2.6.4 Implementation of fishing effort limits

Considering the imperfections of the catch quota system and its limited influence on maintaining the stock at a level corresponding to its maximum production, the idea was put forward to limit and monitor the fishing effort (Newman, 1977). This idea is a direct consequence of the method of fixing the TAC at a level of fishing effort corresponding to f_{MSY} or $f_{0.1}$, assumed by ICSEAF.

It is true that the introduction of the fishing effort limit corresponding to the catch quota assigned a given country would make the evaluation of the actual exploitation level much more credible and would make it possible to monitor the fishing effort itself.

The first step towards limiting fishing effort was the introduction in 1983 of a duty to report to the ICSEAF Secretariat any entry and withdrawal from a fishing ground of hake fishing vessels (ICSEAF, 1984d).

However, the implementation of fishing effort limits would require, besides the above purely formal step, additional analyses and decisions, often quite complex due to the international character of the fishery and diversified parameters of vessels used for hake, as well as to the difficulties concerning the choice of the standard effort unit and effort allocation, taking into account predicted c.p.u.e. value for the next year (ICSEAF, 1982; ICSEAF, 1983c; ICSEAF, 1984b; Wysokiński, 1982a).

The analysis of the possibility of introducing fishing effort limits and enforcement, made within ICSEAF in 1984, showed that because of the revealed, objective difficulties, this system may, and should be, introduced on a voluntary basis by each country taking part in hake fishery (ICSEAF, 1984b; ICSEAF, 1984g; ICSEAF, 1985).

A general conclusion to be drawn from the comments on hake regulatory measures is that the lack of sufficiently reliable information and often uncritical acceptance of the available data and their introduction into complex mathematical models may lead to faulty estimations, leading to wrong recommendations in the sphere of management.

In addition the estimation of quota from production models assumes that stock size and recruitment level are driven by fishing effort exclusively. When environmental effects on recruitment are important, as seems to be the case here, the method is faulty and leads to over-estimate of quotas in years of low recruitment and vice versa (Garcia, 1984).

On the other hand, cautious determination by ICSEAF of allowable rate of exploitation at a safe level ($f_{0.1}$) or at 10% below $f_{0.1}$ (employed recently by the Republic of South Africa in Division 1.6) reduces in some degree the effects of possible estimation errors. Safe strategy makes it possible to maintain the stock at a level at which fluctuations in recruitment are reduced due to the formation of a "buffer" stock. This strategy corresponds to the world-wide tendency of determining exploitation at an optimum level (Optimum Sustainable Yield), and emphasizes the correct determination and practical application of age at first capture (ICES, 1976).

2.3 Kingklip

The biology and ecology of kingklip, Genypterus capensis (family Ophididae) are not too well known. It inhabits the Southeast Atlantic, on the edge and slopes of the continental shelf. The USSR and the Republic of Korea reports its presence in catch statistics as far north as Divisions 1.1 and 1.2. However, the information available in the literature refers only to the coast of West Africa south of 17°S, including Agulhas Bank.

The importance of kingklip in bottom catches and its vertical distribution are presented below on the basis of the results of the Polish expedition on the research vessel "Professor Siedlecki" in November-January 1972/1973 (Morski Instytut Rybacki, 1974):

Division	No. of bottom hauls observed	Investigated depth range (m)	Depth range with kingklip present	Frequency of hauls with kingklip %	& share of kingklip in hauls with kingklip	% share of kingklip in all hauls
1.3	7	180-710	435-710	28	1.5-6,6	0.5
1.4	23	200-450	200-450	65	1.5-29.0	3.9
1.5	19	180-510	200-510	79	1.5-50.0	7.3
1.6	21	240-1040	250-600	33	1.1-30.6	2.0
Subarea 2	15	250-760	390-760	80	1.0-78.0	6.9

There is no information on migrations of kingklip but its catches increase in Division 1.5 in the first half of the year, while in Division 1.1 and Subarea 2 in the second half (ICSEAF, 1984c).

Kingklip is believed to be a long-lived, slow-growing fish. In the Polish catches off the West African coast, specimens 35-100 cm in length were found, while on Agulhas Bank fish 70-137 in length, with a visible absence of young age groups (Wrzesiński, 1975). In the Spanish catches made in Division 1.5, fish had lengths of 41-131 cm, age 6-31 years with a predominance of specimens with lengths of 74-86 cm, age 10-18 years (Sanchez et al., 1984).

In the Soviet catches in Divisions 1.3 - 1.4 fish aged 1-3 years constituted 23% and fish older than 8 years only 1.8%, with the predominance of 4-7 year olds (Isarev, 1983).

It is not known whether such significant differences in age composition of Soviet and Spanish catches are a result of different age interpretation, different area and depth of fishing grounds where both fleets operated, or mesh size of the trawl.

The stock parameters given by various authors also exhibit great differences:

L_∞ cm	W_∞ kg	K	t_o years	t years	t_c years	t_r years	M	F(opt)	Authors
170.0	-	0.05	-1.20	31	-	-	0.15	-	Wrzesiński, 1975
114.2	-	0.06	-4.08	31	6	-	-	-	Morales, 1980
150.2	31.0	0.07	-1.54	17[1]	5[1]	4[1]	0.30	0.60	Div.1.5+1.6 Isarev, 1980
174.4	34.4	0.06	-1.21	23	8[1]	5[1]	0.20	0.40	Div. 1.5+1.6 Isarev, 1980
120.1[2]	12.9	0.13[2]	0.16[2]	-	5.9	4	0.30	0.21	Terré, 1980

1/ Optimum target values

2/ After Payne, 1976, cited by Terré, 1980

It is particularly unclear why the authors differ as regards age of first capture, fishing mortality (F_{opt}), and life-span, depending on the statistical division. The results of investigations on stock separation and the possible, multi-directional stock migrations in a function of age and season, which could influence such differentiation, are not yet known.

Catch statistics in the years 1972-1983 does not exhibit substantial fluctuations, with the exception of 1973, when a maximum catch of 21 660 tons was made, and the last two years (1982-1983), when a slight drop was observed, probably caused by the reduced total fishing effort (Table 16).

The size of the catches given above is - according to some authors - underestimated and in reality is 2-3 times greater because some countries report kingklip catches under "other fish" (Isarev, 1983).

Kingklip does not form large concentrations, which would allow for directed fishery. It usually constitutes a by-catch in the hake fishery of almost all countries specializing in demersal fishery (e.g., the Republic of South Africa and Spain) - see Table 17.

The evaluation of stock status, because of different initial data, varies. The pessimistic view, based on cohort analysis and official catch reports, is that if catches in Subarea 1 remain for a longer period of time at a level of 7 000 tons, while the rate of exploitation (F = 0.36) and recruitment remain at the current level (mean from previous years), then the stock biomass will drop by 40% and catches by 30% (Terré, 1980). According to the optimistic view, based on different fishing patterns and the assumption that catches reported so far were considerably underestimated, optimum catch in Divisions 1.3-1.6 should be 32 900 tons, with F = 0.4 or F = 0.6, depending on division (Isarev, 1983).

Taking into account the uncertainty of the above evaluations, as well as the slight fluctuation of catches in the years 1972-1981, little can be said to recommend a change of the exploitation scheme used so far for hake fishery where kingklip appears as by-catch only (ICSEAF, 1983c). A similar view is also suggested for the Agulhas stock by fairly satisfactory catch results of OTB-5 vessels (Republic of South Africa). These results attained in Subarea 2 in the past few years are presented below:

Table 16

Global catches of Genypterus capensis in the ICSEAF Area in the years 1972-1983 by Division (in tons)

Areas year	Total 1/ convention area	Total SBA 1	Div. 1.1	Div. 1.2	Div. 1.3	Div. 1.4	Div. 1.5	Div. 1.6	Total SBA 2
1972	16 311	10 862	1 050	788	1 606	2 471	3 118	1 829	1 154
1973	21 657	16 417	59	36	38	5 372	10 740	172	299
1974	12 876	8 346	69	327	13	1 839	5 240	533	1 042
1975	10 611	10 201	521	524	3	1 962	3 057	276	410
1976	14 444	11 811	295	390	211	5 384	3 447	2 084	2 633
1977	11 998	10 762	45	88	134	2 941	5 211	2 246	1 236
1978	11 528	9 101	141	482	242	1 749	4 652	1 835	2 425
1979	11 317	8 901	1 818	605	122	1 076	3 301	1 979	2 416
1980	10 521	8 060	764	456	89	1 454	2 172	3 125	2 283
1981	10 028	8 450	114	45	139	2 392	3 257	2 458	1 578
1982	7 444	6 224	1 503	649	128	741	1 460	1 711	1 220
1983	9 289	7 769	1 325	2	57	741	2 874	2 770	1 520

Source: ICSEAF Stat.Bull. Nos 2-12 and ICSEAF, 1984c

1/ Including not known division

Table 17

Kingklip catches in 1983 by country and Division (ICSEAF, 1984c)

(in tons)

Country Division	South Africa	Spain	Japan	USSR	Rep. of Korea	Other	Total
1.1	-	-	-	1 171	154	-	1 325
1.2	-	-	-	-	2	-	2
1.3	1	29	-	27	-	-	57
1.4	11	640	-	90	-	-	741
1.5	527	2 186	1	-	1	159	2 874
1.6	2 713	47	-	-	-	10	2 770
2.1	773	-	34	-	-	-	807
2.2	649	-	64	-	-	-	713
Total	4 674	2 902	99	1 288	157	169	9 289

Year	Catch tons	Fishing effort		c.p.u.e.	
		days fished	hours fished	t/d	t/h
1981	57	21	247	2.7	0.23
1982	220	60	492	3.7	0.45
1983	69	18	144	3.8	0.48

Source: ICSEAF Stat.Bull.Nos.11-12 and ICSEAF, 1984c.

2.4 Large-eye and Angolan dentex

Large-eye dentex, Dentex macrophtalmus, is a species exhibiting disjunction occurring both off northwestern (33°40' - 14°50'N) and southwestern coasts of Africa; it has not been observed in the tropical zone.

In the ICSEAF Convention Area it is found in statistical Divisions 1.1 through 1.4, with the parallel 26°30'S as its southern geographical boundary of occurrence (Wysokiński, 1975).

The fishing grounds stretch from Lobito to Walvis Bay at a depth range of 60-300 m; in the cross Division in deeper waters (100-400 m). The boundary depth for the occurrence of this species is most likely 450 m.

In the areas where these fish occur in large numbers, in Division 1.2 and between the Tiger Bay and Cape Frio, in Division 1.3, the USSR carries out directed large-eye dentex fishery. In February-March 1972, the Polish research vessel "Wieczno" attained the following c.p.u.e. (in kg/h), depending on the area and depth of catches (Wysokiński, 1975):

Area	Depth interval in m					
	100-150	150-200	200-250	250-300	300-350	350-400
15°-20°S	368	139	90	20	-	-
20°-25°S	116	50	146	45	17	1
25°-30°S	-	-	-	-	-	0

As is the case with the CECAF Area, the stock migrates towards the shore (in the southern summer) and towards the open sea (in winter). However, there is no information about its possible migrations along the shore.

North of the mouth of the Cunene, a related species, Dentex angolensis, occurs at slightly lower depths; its presence makes it more difficult to estimate the catch of large-eye dentex. However, there are grounds for believing that the share of Dentex angolensis in the catches is not significant. It is impossible to determine its actual share in the catches as both species are usually recorded in statistics under one name - dentex (Dentex spp.)

The catches of large-eye dentex (with an admixture of Dentex angolensis, especially in Divisions 1.1 and 1.2) are presented in Tables 18a and b. A period of the greatest catches may be distinguished here, from the moment the Soviet fleet began fishing operations in 1962/1963 until 1968; they were at a level of 35 000-55 000 tons. The period of smallest catches of 8 000-9 000 tons occurred in the years 1974-1975 and 1980-1981. The drop in catches in 1974-1975 was caused by a considerable reduction of fishing effort related to the independence of Angola. This reduction most likely enabled

Table 18

Dentex catches in ICSEAF Convention Area

a. Total, in the years 1965-1983			
1965	42,4	1975	9,0
1966	51,4	1976	43,0
1967	35,1	1977	26,4
1968	55,4	1978	29,2
1969	18,3	1979	21,1
1970	18,1	1980	9,2
1971	19,4	1981	8,3
1972	19,3	1982	14,1
1973	11,7	1983	11,7
1974	8,3		

b. By statistical division in the years 1978-1983 (Soviet catches in brackets)

Year	1.1	1.2	1.3	1.4	Total
1978	5.4	13.1	9.9	0.8	29.2
	(4.9)	(12.8)	(7.1)	(0.6)	(25.7)
1979	5.3	3.6	11.4	0.7	21.0
	(4.6)	(3.3)	(9.3)	(0.3)	(17.9)
1980	4.9	3.2	1.0	0.1	9.2
	(4.1)	(3.2)	(0.9)	(0.1)	(8.3)
1981	2.3	1.6	4.3	0.1	8.3
	(2.2)	(1.6)	(4.2)	(0.1)	(8.1)
1982	5.8	2.3	5.8	0.2	14.1
	(5.6)	(2.3)	(5.7)	(0.2)	(13.8)
1983	6.3	1.7	3.6	0.1	11.7
	(4.1)	(1.6)	(3.0)	(0.1)	(8.8)

Source: Terré, 1980a - for the years 1965-1977; ICSEAF Stat. Bull. Nos 8-12 and ICSEAF, 1984c - for the years 1978-1983

Table 19

Catch and effort data on panga on the Agulhas Bank fishing grounds (Divisions 2.1 and 2.2) after ICSEAF, 1980a

Fishing year[1]	Catch ('000 t)			Japanese C.p.u.e.[2]	Effective effort[3] in '000 hours fished
	Japan	Other countries[4]	Total	in tons per hour	
1967/68	4.39	2.00	6.39	0.82	7.78
1968/69	6.30	1.80	8.10	0.86	9.43
1969/70	7.51	1.55	9.06	0.91	9.93
1970/71	5.27	1.30	6.57	0.80	8.22
1971/72	4.52	1.25	5.76	0.70	8.25
1972/73	7.36	1.07	8.43	0.63	13.39
1973/74	8.40	0.74	9.13	0.56	16.19
1974/75	8.18	1.04	9.22	0.45	20.22
1975/76	8.66	1.05	9.71	0.35	27.64
1976/77	2.73	1.14	3.87	0.29	13.50
1977/78	3.57	2.13	5.70	0.29	19.66

1/ 12 months from July through June in the next year;
2/ Stock density index = annual catch/annual effective effort in ton per hour/half a degree square block;
3/ Total catch/stock density index;
4/ Interpolation of calendar year catches

the recovery of the stock, thanks to which catches in the years 1976-1979 increased sharply, only to drop again in the early 1980's. Catches have remained at a low level until now, their slight increase in 1982-1983 refers primarily to Divison 1.1 and concerns most likely Dentex angolensis.

The majority of catches is made by the USSR, and - to a lesser degree - by Angola (local fishery); the catches of other countries are insignificant (Table 18b). The share of the USSR in the catches of dentex is great, reaching over 80-90% depending on the year.

Data concerning fishing effort and c.p.u.e. are very scarce and insufficient to estimate the stock. The following series of c.p.u.e. was obtained for vessels in tonnage group 5 (USSR) operating in Divisions 1.1 + 1.2:

Year	Total catch '000 tons	c.p.u.e. t/d
1978	18.5	1.17
1979	8.9	0.85
1980	8.1	
1981	3.9	0.92
1982	8.1	0.88
1983	8.0	0.67

(ICSEAF Stat.Bull.Nos.8-12, and ICSEAF, 1984c)

Length frequency of large-eye dentex in Soviet catches points out that the stock exploited is getting younger (Fig.13). The length range of the fish caught in 1977-1978 was 6-35 cm, in 1973-1975 15-37 cm (Kuderskaya, 1984).

Age and growth rate of dentex have not been determined in a convincing way. However, a cohort analysis was made on the basis of age composition and length frequency of Soviet catches in the years 1965-1978. The data from this analysis, applied to the general production model (Fig.14) indicated that MSY = 21 600 tons, and catch ensuring the safe stock equilibrium at $F_{0.1}$ is from 18 000 to 19 000 tons (Terré, 1980a; ICSEAF, 1980).

The data thus obtained revealed that the biomass (B_{1+}) of the stock dropped from 226 000 tons in 1965 to 72 000 tons in 1978.

The reason for such great fluctuations in biomass in the whole period was most likely the excessive rate of exploitation in the years 1965-1968 and 1976-1978, when the catches were much higher than those allowed for both by the level of the MSY and $F_{0.1}$.

The lack of information makes it impossible to add current estimates to those made in 1980 and interpret the low catches of 1982-1983 as either the result of the poor condition of the stock or reduced fishing effort. However, judging by a pronounced downward trend in c.p.u.e. for OTB-5 trawlers (USSR), there is a justified fear that the stock is severely overfished.

2.5 Panga

Among several species from the family Sparidae inhabiting Divisons 2.1 and 2.2 (Agulhas Bank), panga, Pterogymnus laniarius is of the greatest importance for the fishery. It is a littoral species and in practice cannot be caught outside the coastal waters of the Republic of South Africa.

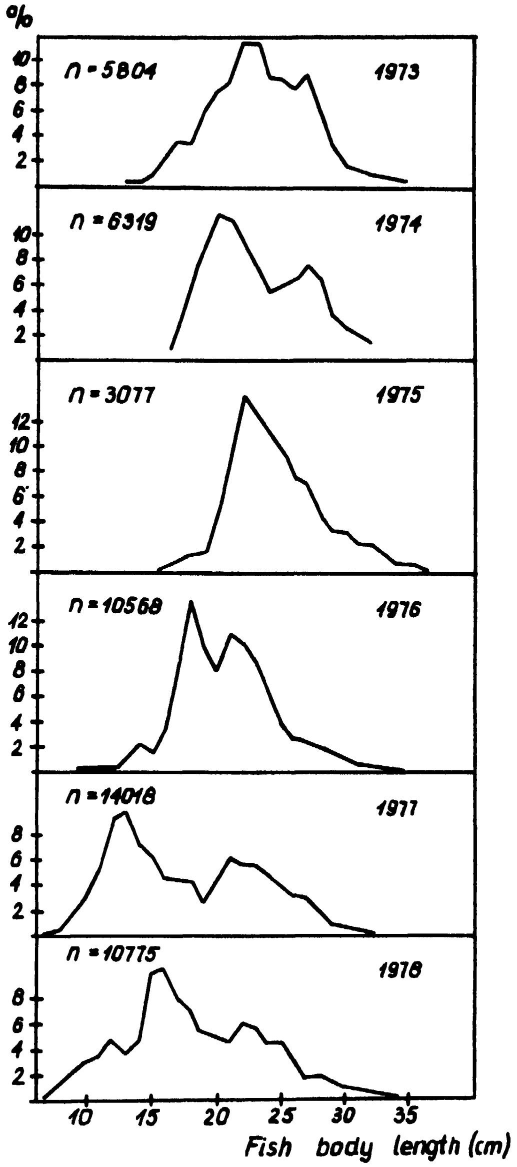

FIG.13 Length composition in percent for Dentex macrophthalmus in Soviet catches on Namibian fishing grounds in 1973-1978 (Kuderskaya, 1984)

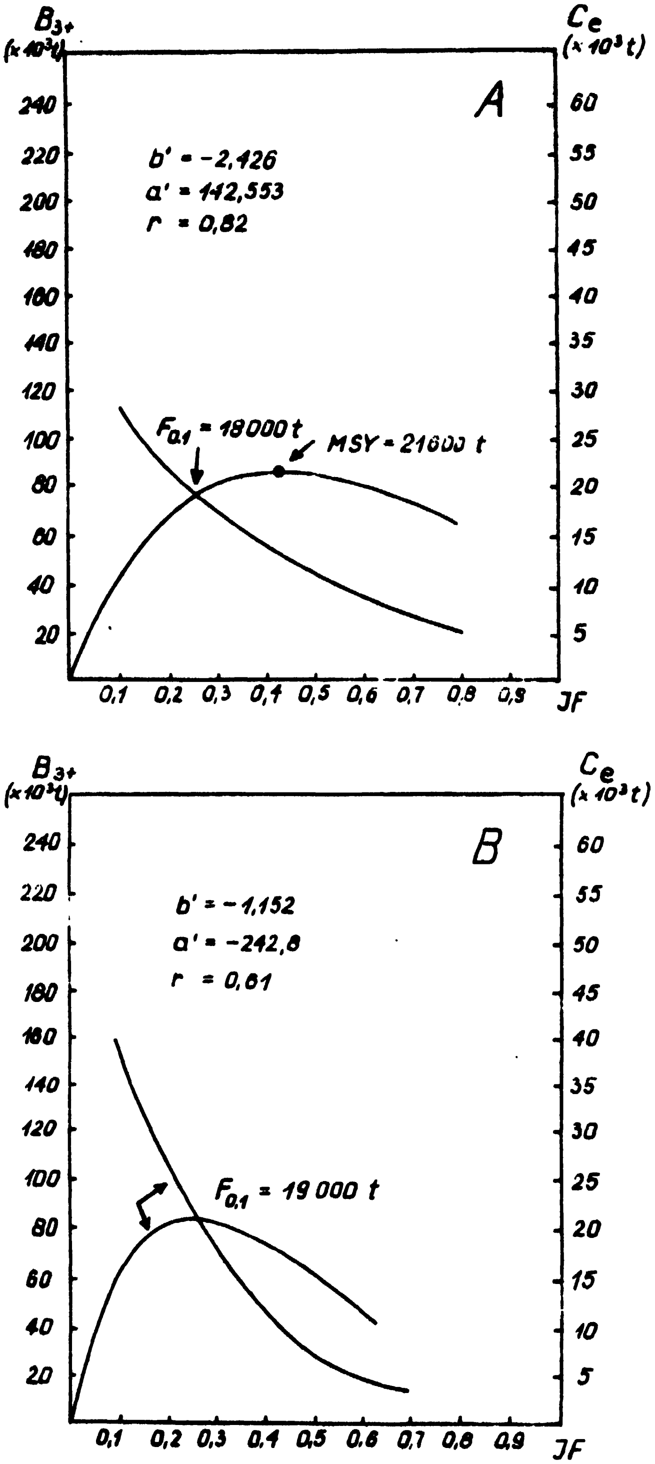

FIG.14 Production model for Dentex macrophthalmus stock based on data from cohort analysis and functional regression
A - with biomass of fish age 3+;
B - with biomass of fish age 1+
(ICSEAF, 1980)

In the years 1963-1977, panga was caught almost exclusively by the Japanese fleet, constituting its major target species. Until 1973, the share of panga in the total catch of the Japanese fleet operating in Divisions 2.1 and 2.2. was 90-95%, and between 1973 and 1977 64-91% (Sato, 1980). When coastal grounds of the Republic of South Africa were closed to foreign fleets and Japan was assigned a small total catch quota, panga ceased to be a target species, appearing in the following years only in the form of by-catch.

In the initial years of the exploitation of the panga stock, a maximum catch of 15 000 tons was reached; after that, the catches remained at a level of 6 000-9 700 tons. In 1976/1977, a considerable drop in catches to 3 900 tons was observed; this trend continued in the early 1980's; catches in 1980-1981 were only 1 600 tons, probably due to strict catch controls introduced by South Africa.

Catch statistics, c.p.u.e. and total fishing effort for the years 1967-1977 are presented in Table 19 (ICSEAF, 1980). For the following years, until 1983, only total catch data are available; there is no information on c.p.u.e. and effort since, as mentioned above, directed fishery was abandoned. The catches in the years 1978-1983 were the following:

1978	4214 tons	1981	1583 tons
1979	3020 tons	1982	1730 tons
1980	1596 tons	1983	1717 tons

The estimated maximum sustainable yield of the stock using these data and the general production models equals: 6 800-7 200 tons (Fig.15).

When estimating the stock by means of cohort analysis, the data on age composition of catches from the years 1967-1977 were used; the assumed natural mortality M was 0.20 and terminal fishing mortality F_t was 0.60. It appears from the analysis that the biomass of the stock (B_{2+}) dropped from 35 000 tons in 1967/1968 to 20 000 tons in 1974/1975. The yield per recruit curve (Fig.16) indicated that F_{MAX} and $F_{0.1}$ should be at a level of 0.28 and 0.21, respectively. These values, transposed onto the size of maximum and safe fishing effort by means of the catchability coefficient were respectively for:

$$\underline{f_{MAX} = 14\ 000 \text{ hours}} \quad \text{and} \quad \underline{f_{0.1} = 10\ 000 \text{ hours}}$$

It appears from the comparison of fishing effort at the level of $f_{0.1}$ and the corresponding catch (6 800 tons) with the real effort and catch (Table 19) that in the years 1972-1977, the allowable exploitation levels were considerably exceeded.

At present, the situation of the stock is unclear. On the one hand, joint scientific expeditions of Japan and South Africa pointed out that stock biomass in the years 1980-1982 was relatively high, equalling 45 500, 48 300, and 31 400 tons, respectively, i.e., at the same level or slightly higher than in 1967/1968, when the stock was in good condition. On the other hand, vessels of the Republic of South Africa did not achieve satisfactory results in directed fishery carried out in the same period due to the low remuneration (ICSEAF, 1983c).

Until more current information is obtained, the most rational recommendation would be to maintain catches at a level not exceeding 6 000 tons per annum.

2.6 Sole

There are two species of sole in the ICSEAF area: Austroglossus pectoralis inhabiting Agulhas Bank with the main fishing grounds located between Cape Agulhas and East London, and Austroglossus microlepis occurring off the coast of Angola and Namibia. In Division 1.6, separating the two populations, it appears sporadically and is not recorded in the catches. Both species are coastal ones, mainly caught in a depth range down to 100 m in territorial waters although in Division 1.4, their presence has been observed down to a depth of 300 m.

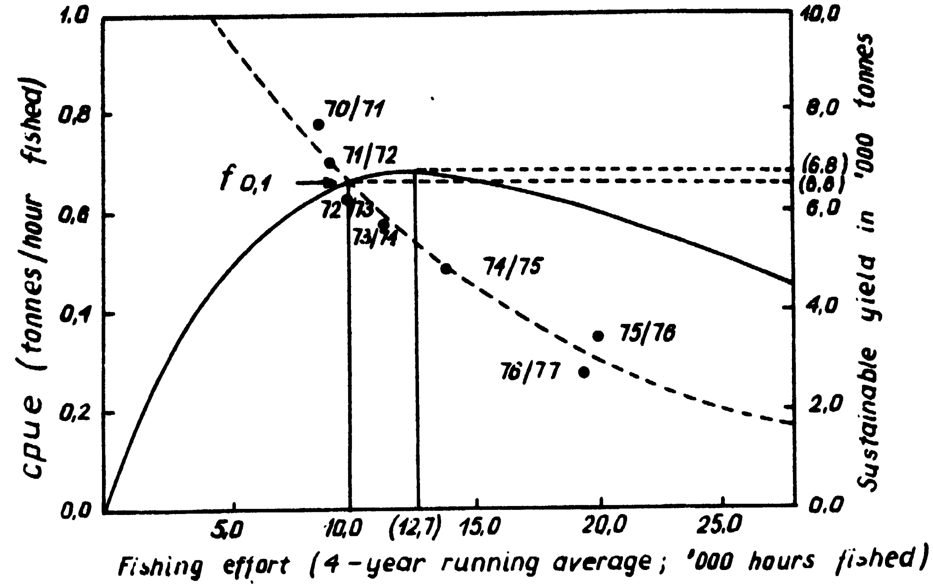

FIG.15 Relation between c.p.u.e. and fishing effort (broken line), and sustainable yield curve (solid line) for panga in ICSEAF Divisions 2.1 + 2.2 (ICSEAF, 1980)

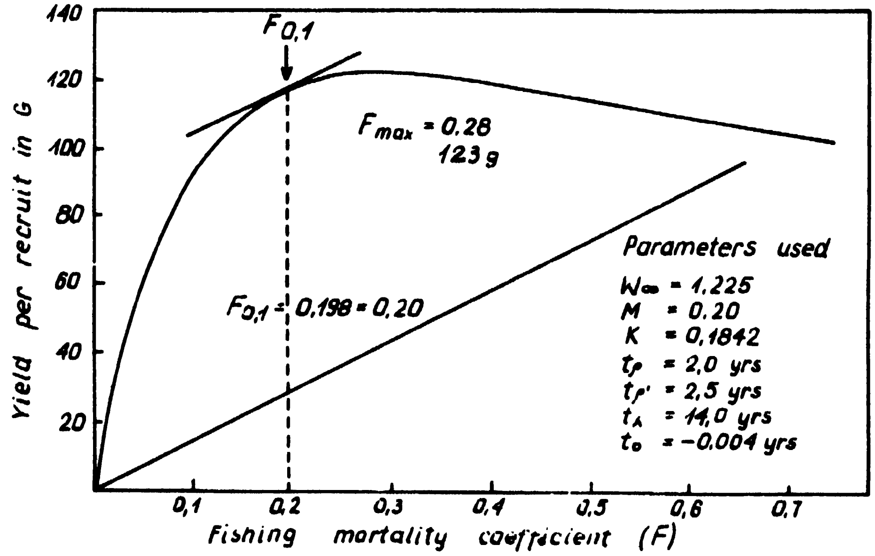

FIG.16 Curve of yield per recruit when the age of first capture is constant and fishing mortality is variable (ICSEAF, 1980)

Catches consist of sole with lengths of 25-45 cm. The maximum observed length was 75 cm.

Although their catches are small, sole is believed to be one of the most valuable species, especially in the Republic of South Africa. Off the coast of Angola, sole is caught practically exclusively by the USSR. In Divisions 1.3-1.4-1.5 mostly by the Republic of South Africa and, to a lesser degree, by Spain, and "Agulhas" sole in Divisions 2.1 and 2.2 at present - exclusively by the Republic of South Africa (Table 20).

The Agulhas sole stock has been exploited by means of a trawl since 1899 by small wooden vessels with a length of 18 m. The first regulatory measure was introduced in 1935, prohibiting the use of mesh size smaller than 75 cm; it is still in force today. Until 1972, directed fishery for that species was carried out; later, when large stocks of hake appeared and advancements in fishing technique took place, sole became a secondary species (Botha, 1978).

The catches and the corresponding calculated fishing effort for the years 1972-1979 have made it possible to determine the maximum sustainable yield (MSY) at a level of 930 tons (Fig.17) (Badenhorst and Sims, 1982). At present, there is evidence suggesting that the condition of the sole stock is satisfactory (ICSEAF, 1985a), i.e.:

- since 1980, the stabilization of fishing effort expended has been observed, at a level well beneath the one determined by the $f_{0.1}$ level;
- there has been a marked decline in the share of sexually immature fish in the catch: from 50% in 1978 to 20% in recent years;
- catches have not exceeded the allowable level thanks to effective control measures and enforcement.

Since no directed fisheries are being conducted at present, it is suggested that not fishing effort but the size of catch at a level of MSY be limited.

For the west coast sole, there is no detailed information allowing for stock assessment except for catch data (Table 20). On the basis of the presented series of data on the size of its by-catch it may be inferred that the size of the stock undergoes cyclic, long-term fluctuations. At present, after a period of large catches with a peak in 1982 (3 800 tons), the stock once again exhibits a slight downward trend.

Most likely, the level of maximum sustainable yield does not exceed 2 000-3 000 tons.

2.7 Monkfish (Lophiidae)

The systematic position of species reported in catch statistics under the name monkfish or anglerfish is still the object of intensive studies. At present, two genera are being distinguished: Lophius and Lophioides; within the genus Lophius two species L. upsicephalus inhabiting the edge and upper slope of the shelf (100-500 m) and L. vaillanti, a deep-water species, occurring below a depth of 400 m (ICSEAF, 1985a). However, in the light of the results of electrophoretic investigations and meristic features of L. upsicephalus (Grant and Leslie, 1984), the systematic position of species belonging to the genus Lophius is still being discussed and new information continues to pour in (Lloris and Rucabado, 1985).

According to the Spanish data (Sanchez et al., 1984), length range cf monkfish caught in Division 1.5 is 33-117 cm, with fish 54-62 cm in length predominating; 80% of the fish investigated were over 8 years old.

Monkfish usually occur as a negligible by-catch in the hake fishery; in the 1970's it equalled 30-115 kg per day fished of a tonnage group 8 trawler, i.e., over 2000 GRT (Macpherson, 1975).

Table 20

Total catches of sole in the ICSEAF Area in the years 1972-1983 by statistical division

Species	*A. microlepis*						*A. pectoralis*		
Division Year	Total SBA 1	Div. 1.1	Div. 1.2	Div. 1.3	Div. 1.4	Div. 1.5	Total SBA 2	Div. 2.1	Div. 2.2
1972	1 379			1 160	219		1 054	1 054	
1973	1 990			400	1 583	7	970	970	.
1974	985			279	663	43	611	611	
1975	570[1]			16			762	762	
1976	234			86	148		890	773	117
1977	738[1]	35	181	97	325	88	809[1]	521	128
1978	1 495	359	37	367	728	4	1 035[1]	996	38
1979	1 877	437	87	413	932	7	900[1]	853	46
1980	1 194	423	198	336	236	1	941	886	55
1981	2 335[1]	426	148	643	1 096	20	1 026	971	55
1982	3 826	1 259		1 583	968	13	817	773	44
1983	1 828	926	16	142	685	59	683	635	48

[1] Together with catches in an unknown division

Source: ICSEAF Stat.Bull. Nos 2-12 and ICSEAF 1984c

Table 21

Total catches of Lophiidae in the ICSEAF Area in the years 1978-1983

Total convention area		1.1 + 1.2	1.3 + 1.4 + 1.5	1.6 + 2.1 + 2.2
1978	11 633	262	7 359	4 006
1979	7 924	25	3 535	4 334
1980	8 190	-	3 203	4 682
1981	19 296	-	15 007	4 269
1982	19 149	-	15 206	3 928
1983	15 568	-	11 917	3 651

Table 22

Total catches of other demersal fishes in the ICSEAF Area, 1978-1983

Total convention area		1.1 + 1.2	1.3 + 1.4 + 1.5	1.6 + 2.1 + 2.2
1978	62 712	26 303	30 427	3 060
1979	49 008	25 583	14 787	5 694
1980	32 997	21 248	4 366	6 003
1981	37 181	13 444	17 305	4 578
1982	40 726	19 393	16 316	3 932
1983	48 918	17 912	21 835	4 626

Source: ICSEAF Stat.Bull. Nos 8-12 and ICSEAF, 1984c
Cartilaginous fishes not included

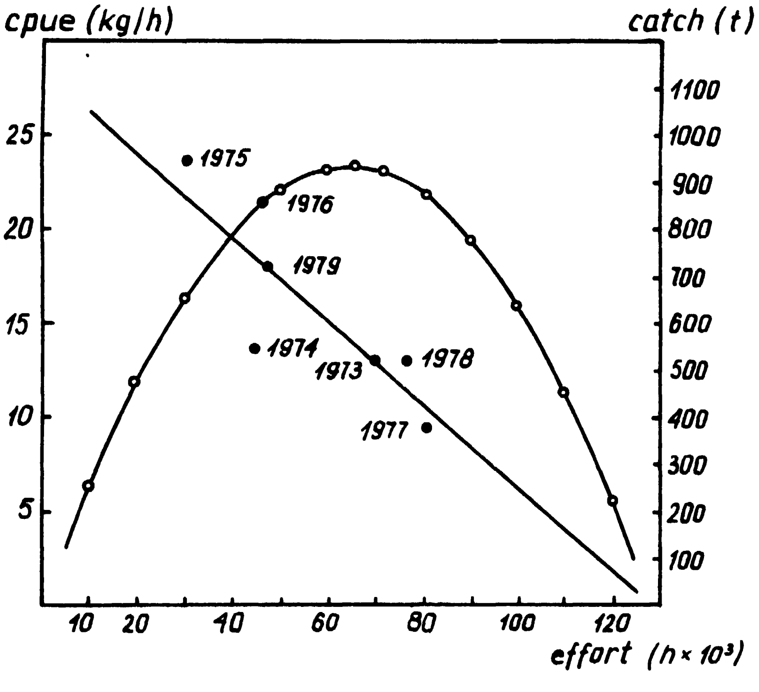

FIG.17 Yield curve and c.p.u.e. trends for the Agulhas sole (Badenhorst and Sims, 1982)

In recent years, however, the Spanish fleet discovered monkfish concentrations in Divisions 1.4 and 1.5; they make it possible to carry out directed fishery from time to time. As a result monkfish catches in these Divisions increased 4-5 times, and in the whole Convention Area from 8 000 tons in 1979-1980 to about 20 000 tons in 1981-1982. In the remaining divisions, the catches have remained at the same level for the past several years (Table 21).

The lack of more detailed data makes it impossible to estimate stocks of monkfish and determine the impact of the fishery on their status. On the basis of the current statistics, it may be said that their potential catch is between 10 000 and 20 000 tons.

2.8 Other demersal fishes

A number of demersal species of commercial value has been omitted during stock estimations because of the low abundance of their populations. The range of their occurrence is usually limited to the local littoral zone, or else they may be found in the whole ICSEAF area in scattered forms. In catch statistics they are frequently reported under "other fish" so it is impossible to define accurately the real catch of any of them. However, they could be of considerable importance for the coastal fisheries, especially in areas with dense population (Angola, the Republic of South Africa, Mozambique). They are caught using various boats, pirogues, small trawlers with a variety of gear: beach seines, trawls, set nets, surrounding nets, hooks, etc.

Among more valuable species some of them are worth mentioning, especially littoral forms as: meagres and other croakers (Sciaenidae), grunters (Pomadasyidae), threadfins (Polynemidae), groupers (Serranidae), snappers (Lutjanidae), catfishes (Ariidae), small-eyed dentex and other sea breams (Sparidae), congers (Congridae) and among large distributed but scattered species: scorpionfishes (Scorperidae), gurnards (Triglidae), John Dories (Zeidae), different flatfishes (Pleuronectiformes), redfishes (Berycidae), skates (Rajidae) and several other demersal cartilaginous fishes.

Among "other demersal fishes" there are no less numerous non-commercial species, used for fish meal production on board trawlers. It is worth mentioning the following: Synagrops sp., Chlorophthalmus sp., several species called soldierfishes, Gobidae, Epigonus, demersal lanternfishes, etc.

The total annual catch of those various fishes was 50 000 tons in the past 6 years (1978-1983) (Table 22). A comparison of catches in the past 20 years did not reveal any substantial changes. Until more recent information is obtained, this last fact suggests that the potential catch should be assumed at the level of the mean catch attained so far.

It is generally believed that the fishery based on demersal species from greater depths has very small perspectives for development. However, some of these fish may assume greater importance in the future, when fishing technique on shelf slopes, characterized by great drops in its level, underwater rocks, etc., has been mastered. The expeditions of the Polish research vessel "Professor Siedlecki" have detected a number of large and dense fish concentrations above the bottom with the help of hydro-acoustic equipment; it was not possible to catch these fish with trawls. Some of these concentrations at depths of 700-1200 m were identified as black John Dory (Allocytus verucosus) - a good-tasting commercial species (Morski Instytut Rybacki, 1974).

Technological progress in processing could make it possible in the future to utilize for human consumption the species at present used for the production of fish meal, for instance, Chlorophthalmus, Synagrops, lanternfish, soldierfish, of which from several to ten thousand tons are landed per annum.

2.9 Horse mackerel

2.9.1 Distribution and stock separation

The coastal waters of Western Africa are inhabited by two species of horse mackerel: Trachurus trachurus L. and T. trecae Cadenat. Off the coast of the Republic of South

Africa, in Divisions 1.6-2.1-2.2, lives a separate geographical form considered usually as a subspecies, *T. trachurus capensis* Castelneau, known under the local name "maasbanker".

Because of external similarities of the two mentioned species, it is believed that they are only subspecies, belonging to one species, *Trachurus trachurus*. In the ICSEAF Area, it has been proposed to call them, respectively: *T. trachurus capensis* (or *T. trachurus trachurus*) and *T. trachurus trecae* (Draganik, 1977, after Letaconnoux, 1951). However, ICSEAF recommended the use of traditional names of species, mentioned in the introduction (ICSEAF, 1975).

T. trecae inhabits the subtropical and tropical zones, occurring uninterruptedly between 26°N (Cape Bojador) and approximately 17°30'S (Cunene river estuary) while the occurrence of *T. trachurus* is characterized by disjunction. It is found in the northern hemisphere beginning with the North Sea, along the western coasts of Europe and Africa down to Cape Vert. Beneath this point, only single young specimens may be encountered; still farther south the species does not occur, reappearing off southern Angola (Wysokiński, 1973). Beginning with Mossamedes, the population of *T. trachurus* increases in numbers - in Division 1.3 it is an unquestioned dominating species. In Division 1.5 and northern part of Division 1.6, it is much less abundant. This area is probably the boundary one for the Namibian stock and subspecies *T. trachurus capensis* from the South African region, believed to constitute a separate stock (ICSEAF, 1979).

As is the case with hakes and sardinellas, no distinction is made in catch statistics among the different species or forms of horse mackerel; they are reported under one name. However, on the basis of the knowledge of the geographical distribution of each species, the Cunene river estuary is assumed to be the southern boundary of the occurrence of *T. trecae* while the northern boundary for *T. trachurus* is believed to run farther north, at least along the parallel 15°S (Ritzhaupt, 1980).

Since the Cunene river is also the state border between Namibia and Angola, it is not difficult to determine the species affinity of horse mackerel taken on the international fishing grounds of Namibia; as assumed above and confirmed by additional observations (Wysokiński, 1979; ICSEAF, 1979), they belong to *T. trachurus*.

The USSR, which conducts fishing operations both south and north of the Cunene river, reported that between the river and 15°S (northern part of Division 1.3) the ratio of *T. trachurus* to *T. trecae* in the catches is 61.1 to 38.9% (ICSEAF, 1982a).

The separation of horse mackerel stocks in Division 1.3 is of special importance. The greatest concentrations of both species are observed in the frontal zones of the Benguela Current (cold), with which *T. trachurus* is associated, and the Angola Current (warm), which meets the needs of *T. trecae*. The frontal zone of both currents occurs as a rule in Division 1.3 but depending on the activity and range of one of these currents, horse mackerel stocks may move correspondingly and it is theoretically possible for them to go beyond the boundaries established above.

In the light of the present knowledge of the ecology of horse mackerels, it is possible to distinguish among them three main stocks in the ICSEAF Area:

(i) The Angolan stock belonging to the species *T. trecae* and inhabiting ICSEAF Divisions 1.1, 1.2 and the northern part of Division 1.3 (Angolan coast);

(ii) The Namibian stock (*T. trachurus*) inhabiting Divisions 1.3, 1.4 and 1.5 (coast of Namibia and southern Angola);

(iii) The "Agulhas" stock considered to belong to the subspecies *T. trachurus capensis* and inhabiting Divisions 1.6, 2.1 and 2.2 (coast of the Republic of South Africa).

There is probably a great deal of inter-mixing between the Namibian and Agulhas stocks, especially in Divisions 1.5 and 1.6. However, since catches in Division 1.5 are insignificant, this question is not so important for the estimation of these stocks. A customary name for fish belonging to both these stocks is Cape horse mackerel while the fish from the Angolan stock are called Cunene horse mackerel.

Investigations on horse mackerel stock assessment are in practice carried out taking into account the above separation although, obviously, further observations need to be continued.

Horse mackerel, irrespective of its species affinity, live in shoals and inhabit the near-bottom zone of the shelf and its edge, as well as the pelagic zone. That is why they may be taken with bottom and pelagic trawls, and purse seines. The near-bottom concentrations are observed in the 60-270 m depth range (maximum of 300 m), but most often they occur between 120 and 180 m. Pelagic concentrations may form either over the shelf or over greater depths. For instance, in the first half of 1982, large concentrations of *T. trachurus* were observed in Division 1.3 both over the shelf and depths reaching down to 3 500 m, in the water layer between 20 and 300 m from the surface (Wysokiński, in press).

Juvenile horse mackerel occur frequently in the shallower coastal zone at smaller depths than 30 m; upon reaching a length of 15-20 cm, the fish are recruited to the adult stock and no dependence of vertical distribution in a function of fish length and age is then observed.

Horse mackerel concentrations are of quite a permanent character, their migrations rare and usually caused by environmental local changes. Thus, fishing operations may be conducted all year round. The density of fish in their concentration areas may be quite considerable, often resulting in the phenomenon of saturation (the catch exceeds processing capabilities of the vessel). It is not rare to attain a catch of 20 tons per one hour fished (Komarov and Kudersky, 1963).

2.9.2 Biological stock parameters

2.9.2.1 *Trachurus trecae* (Angolan stock)

Information on the Cunene horse mackerel - Angolan stock-is scarce. Until 1973, the stock was exploited mostly by purse-seiners in the coastal zone, at small depths, inhabited by the younger part of the stock. The majority of fish taken in the Lobito area did not exceed 3 years of age. The fish belonging to these age groups had the following lengths (Marecos, 1974):

Age group	Fork length cm
I	12.3
II	17.4
III	22.3

The above author found it impossible to determine growth parameters of the species because of low representation of samples (no large fish). However, the length-age relationship presented above is similar to that observed in young *T. trachurus*.

In the light of investigations of *T. trecae* in the CECAF Area it is also evident that its growth parameters are similar to those of *T. trachurus*; it is thus unlikely that the former may have an asymptotic length two times smaller and Brody growth coefficient K three times smaller than *T. trachurus* (Draganik, 1977, after Campos Rosado, 1972). Besides that in the CECAF Area between 15° and 19°N, the largest specimens of *T. trecae* observed in the catches had a length of 50 cm (Boely *et al.*, 1973).

The view that growth rate of both species off the NW and SW coasts of Africa is similar was confirmed by recent Soviet investigations of age and length composition of the exploited adult Angolan stock (Venediktova, 1985). The following parameters were obtained:

$L_{\infty} = 45.5$ cm, $K = 0.18$, $t_0 = 1.76$.

This horse mackerel is fit for harvesting at age 1+ (length 15-17 cm) and disappears from the stock at the age of 6 years. Two and 3-year olds predominate in the stock; this age more or less corresponds to the age of first sexual maturity (2.6 years).

2.9.2.2 *Trachurus trachurus* (Namibian stock)

Length and age composition of catches indicates that all age groups are subject to fishing mortality, beginning with a length of 6 cm (age group 0), to a length of 65 cm, the longest specimen observed (Komarov and Kudersky, 1963).

With the progress in intensive exploitation of the stock, mean length of fish taken with a trawl decreased systematically from 26-32 cm (4-6 year olds) in 1972-1973 to 23-25 cm (3-4 year olds) in 1981-1983. This was accompanied by a parallel phenomenon of the reduction of the length, at which 50% of fish reach first sexual maturity: from 26.9 cm in 1977/1978 to 23.5 cm in 1983. These trends were arrested after 1981, when the minimum mesh size of 60 mm had been introduced in the trawl fishery; however, mean length of fish in the catch remained until 1983 at the same, low level (Wysokiński, 1984).

Although recruitment to the adult stock, caught with trawl on international fishing grounds (beyond the coastal zone of 13.5 miles) is taking place at lengths of 17-22 cm (Draganik, 1977), all these observations are of little value because the purse-seine coastal fishery uses a mesh size of 11 mm this fishery could have a considerable impact on the condition of the whole stock (ICSEAF, 1985a).

Mean length of young horse mackerel taken with purse seines with a mesh size of 11 mm is between 9 and 18 cm, depending on the season (with total length fluctuating between 5 and 20 cm and mean 10 cm); these catches are quite substantial; for 1983, this figure constitutes 17.5% of total Namibian horse mackerel catches of all states and over 90% of South African catches (ICSEAF, 1984h; ICSEAF, 1984c; ICSEAF, 1983b; and ICSEAF, 1984f). However, it should be noted that the catches of juvenile horse mackerel by coastal purse seiners are not always so high and undergo considerable fluctuations, from several thousand tons to a high of 140 000 tons in 1971 (Table 5).

Growth parameters of *T. trachurus* were determined by several authors between 1971 and 1984. Asymptotic length ranged, depending on the author, from 41.1 to 64.9 cm; Draganik and de Santaella (1984) believe that the values of 50.9-51.3 cm are closest to the actual values. The value of K fluctuates from 0.093 to 0.19, the most recurring being 0.11-0.13. These differences, which are not without impact on the age composition of catches, are usually the result of different age interpretation from otoliths and different systems of assigning a given specimen with a known age to a year class or age group. A guide for age determination in horse mackerel currently prepared by ICSEAF experts will no doubt reduce the hitherto existing divergence of opinion in this respect.

Other stock parameters are as follows:

Recruitment to the exploited stock on international fishing grounds is extended in time. It begins at a length of about 15 cm and an age of 1.5 years (Wysokiński, 1981) and last until year 3 inclusive. At age 4, the stock is believed to be fully recruited (Mahnke and Bormann, 1980; Babayan *et al.*,1985a).

Age at first capture (optimum) defined, when M = 0.55 and K = 0.11 is 2.44 years - at a length of about 21 cm (Komarov *et al.*, 1980).

Maximum age of horse mackerel is variously estimated, even as high as 21 years (Shcherbich *et al.*, 1980). For the purpose of stock assessment it is assumed that t_λ = 15 years (Terré, 1977).

Natural mortality determined by Draganik (1978) at a level of M = 0.4 has been so far accepted by ICSEAF experts. Other extreme estimates are 0.3 (Terré, 1977) and 0.55 (Komarov *et al.*, 1980).

Length-weight relationship coefficients fluctuates from year to year and season to season. The values of long-term means (1950-1983) are:

$A = 7.528 \times 10^{-3}$ and $B = 3.032937$ (Wysokiński, 1985).

Condition factor ($K = \frac{100\ W(g)}{L^3\ (cm)}$ in the years 1981-1983 depended on the season. The lowest value has been observed in July (0.74), the highest in February (0.86) (Wysokiński, 1985).

Selection coefficient fluctuates between 4.02 and 4.28. It is suggested that an intermediate value of 4.19 be assumed (de Villiers, 1977).

2.9.2.2 Trachurus trachurus capensis (South African stock)

The biological parameters of the South African stock (T. trachurus capensis) are not distinguished because of their similarity to the parameters of the Namibian stock.

2.9.3 Catches

The first information on the catches of horse mackerel came from Division 1.6 and the Angolan coast in the 1950's, although it had been fished much earlier. Until the 1960's, it was taken almost exclusively by purse seine. At that time, horse mackerel in Division 1.6 was caught together with pilchard, and off the coast of Angola, together with sardinella; the catches amounted to 50 000 - 100 000 tons per annum in each of these areas. Purse seine fishery for horse mackerel continues to operate in both areas although it has been largely replaced by the trawl fishery.

Off the coast of Angola, up to the time of independence, Angolan horse mackerel landings from purse seiners reached a high of 100 000 - 170 000 tons; after independence they have remained at a stable level of 65 000 - 75 000 tons. The share of horse mackerel in purse seiner catches in Division 1.6 dropped in the 1970's and 1980's to 1-5 tons per annum only.

In the waters off Namibia, purse seine fishery was started in 1970 and continued until 1983 with varying results, from 0 to 140 000 tons (Table 5).

The rapid development of the horse mackerel fishery began in the early 1960's, when the new trawl technique was introduced and several autonomous long-range fleets from Europe and Asia began fishing operations in the ICSEAF Area. The development of the local onshore network of fish meal plants also contributed to this sudden expansion. In the years 1966-1970, catches of horse mackerel in the Convention Area doubled when compared with the 1950's, equalling 200 000 - 300 000 tons, and increased to 500 000 tons in 1976. The maximum catch in the ICSEAF Area was recorded in 1978 - 966 000 tons. Between that year and 1984, they remained at a level of 700 000 - 800 000 tons (Table 23).

According to the stock separation of horse mackerel mentioned above, catch estimations of each of them are presented in the table separately. The catch of T. trecae from the northern part of Division 1.3 was estimated on the basis of the differences between the total catch of horse mackerel in Divisions 1.3 + 1.4 + 1.5, as recorded in ICSEAF Statistical Bulletins Nos. 1-12 and ICSEAF, 1984c, and the catch of T. trachurus in these divisions accepted by the ICSEAF Standing Committee for Stock Assessment (ICSEAF, 1985a). However, there are certain doubts as to the accuracy of separation among species of the catch in 1977-1979 in Divisions 1.3 + 1.4 + 1.5. They seem to be underestimated for T. trachurus - Namibian stock - and, as a consequence, overestimated for the catch of T. trecae of the southern coast of Angola. Under- and overestimation concerns at least 100 000 tons. On the other hand, a sudden increase of the T. trecae catch from 1977 could have resulted in an intensive exploitation of the Angolan fishing grounds by the Soviet fleet. In 1982, the maximum and hitherto unobserved catch of Namibian horse mackerel at a level of 660 000 tons was, among other factors, a result of considering 97 000 tons of horse mackerel caught by the USSR north of the Cunene river as belonging to Namibian stock (ICSEAF, 1983c).

As may be seen from Table 23, horse mackerel catches are concentrated in the northern part of Namibia and southern part of Angola. The catches of the Angolan stock in Divisions

Table 23

Horse mackerel catch statistics in the ICSEAF Area, 1966-1983

('000 tons)

Year	*Trachurus trecae*			*T. trachurus*		Total convention area
	1.1 + 1.2[1]	1.3[2]	Total	1.3 + 1.4 + 1.5[3]	1.6 + 2.1 + 2.2	
1966	5.6	172.1	177.7	99.6	33.7	311.0
1967	3.2	158.2	161.4	72.4	14.7	248.5
1968	6.0	125.4	131.4	69.2	10.5	211.1
1969	4.1	97.5	101.6	46.5	38.1	186.2
1970	1.3	157.6	158.9	50.4	27.5	236.8
1971	5.5	130.1	135.6	214.5	35.2	385.3
1972	53.5	219.2	272.7	72.2	21.6	366.5
1973	8.3	167.6	175.9	271.4	35.6	482.9
1974	4.5	126.1	130.5	193.1	38.5	362.1
1975	33.4	105.1	138.5	242.2	69.2	449.9
1976	37.4	34.7	72.1	456.2	50.4	578.7
1977	45.6	230.8	276.4	352.1	116.1	744.6
1978	62.4	349.7	412.1	516.2	37.3	965.6
1979	75.9	235.8	311.7	401.6	53.6	766.9
1980	52.1	55.9	108.0	544.1	39.2	691.3
1981	47.1	95.0	142.1	590.5	41.2	773.8
1982	57.7	47.4	105.1	660.0	32.2	797.3
1983	58.2	46.2	104.4	606.1	38.3	748.8
1984				530		

1/ ICSEAF Stat.Bull. and Draganik, 1977;

2/ Estimated (as differences between total horse mackerel catch in 1.3 + 1.4 + 1.5 from Stat.Bull. and the catch of Cape horse mackerel in 1.3 + 1.4 + 1.5 accepted by ICSEAF, 1984c);

3/ ICSEAF, 1984 and 1984c

Table 24

Horse mackerel catches by countries in ICSEAF Area in 1978 and 1983

('000 tons)

Country	1.1 + 1.2		1.3 + 1.4 + 1.5[1]		1.6 + 2.1 + 2.2		Total convention area	
	1978	1983	1978	1983	1978	1983	1978	1983
Angola	19.8	24.3	22.1	25.0			41.9	49.3
Bulgaria			25.9	51.2			25.9	51.2
Cuba	0.1		49.7	15.4			49.8	15.4
German Dem.Rep.			26.8	64.5			26.8	64.5
Fed.Rep. of Germany			6.9				6.9	
Ghana	1.8						1.8	
Japan			4.2	0.5	21.9	18.5	26.1	19.0
Rep. of Korea		0.1		1.6				1.7
Poland			122.6	108.3			122.6	108.3
Portugal			0.1	0.0			0.1	0.0
Rumania			27.2	116.2			27.2	116.2
South Africa			9.7	107.1	15.4	19.8	25.1	126.9
Spain			3.2	18.4			3.2	18.4
USSR	40.8	33.9	567.6	144.2			608.4	178.1
Total	62.5	58.3	866.0	652.4	37.3	38.3	965.8	749.0

1/ Including some quantity of *T. trecae* - see Table 23

1.1 and 1.2 (central and northern Angola) as well as those originating in the South African stock (coast of the Republic of South Africa) are insignificant. This is also true about Division 1.5 separating the Namibian stock from the South African stock. In 1980-1983, the mean share of the Angolan stock in the total catch of horse mackerel was 15%, with 80% and 5% contributed by the Namibian and South African stocks, respectively.

The horse mackerel directed fishery is conducted by almost all countries with a centrally-planned economy, using the pelagic trawl technique and operating mainly in Divisions 1.3 and 1.4. In 1978, when the maximum catch was attained, they caught a total of 902 600 tons (93.5% of all horse mackerel catches), with the Soviet share equalling 608 000 tons (63%). The fleet of this country used both trawl and seine techniques, the latter off the coast of Angola. In 1983, the Soviet fleet partly, but significantly, reduced its fishing effort and the catches of countries with a centrally-planned economy dropped to 583 000 tons (78%); at the same time such countries as the German Democratic Republic, Rumania and Bulgaria considerably increased their interest in horse mackerel catches (Table 24).

The Republic of South Africa has been conducting traditional, multi-species purse seine fishery in Divisions 1.3, 1.4 and 1.6. The share of the country in total horse mackerel catches depends on the presence of young fish of this species in the shallow, coastal waters, where purse seiner fleet operates. Greater catches are usually made in more productive years (e.g., 1971 and 1982-1984) (Table 5), and consist of fish from the Namibian stock in Divisions 1.3 and 1.4.

For years the South African stock has been exploited almost exclusively by the trawler fleets of Japan and the Republic of South Africa, with the latter taking small quantities of juvenile horse mackerel with purse seiners in Division 1.6. Each of these countries takes 15 000 - 20 000 tons per annum, with the catches of both amounting to 35 000 - 40 000 tons (Table 24).

The average ratio of purse seiner to trawler catches was the following in the years 1981-1983:

- in the Angolan stock: 61% to 39%
- in the Namibian stock: 10% to 90%
- in the South African stock: 7% to 93%.

2.9.4 Stock assessment and management of horse mackerel stocks

2.9.4.1 *Trachurus trecae* - Angolan stock

The absence of sufficient information on age composition of horse mackerel in purse seine catches of Angola and the USSR as well as about the share of this species in Soviet and Cuban trawler catches makes it impossible to use the existing analytical models for the assessment of the Angolan stock.

The estimations using a parameter of little value - stock density index based on the tonnage of fleet employed in horse mackerel operations - did not give a clear picture of the stock status since an increase in the fleet tonnage was not accompanied by the expected drop in catch per unit of tonnage, but by the opposite, i.e., its increase; this suggests the possibility that other factors operate here than the increase in stock biomass (Newman, 1977; Draganik, 1977).

No further attempts at stock assessment have been made until the present day. The reason is the unsound estimations of the size of catch and the absence of any representative series of data relating the catch to the corresponding fishing effort.

Leaving aside the doubtful statistics for 1977-1979, it may be said that the catches in the early 1980's fluctuated between 100 000 and 150 000 tons, without any visible tendency (Table 23). It is the same level of catches as that observed in the years 1964-1972, suggesting that the maximum sustainable yield may also be contained within these boundaries.

The analysis of the stock situation in the period 1964-1972 made it, at the time, possible to put forth the following conclusions (Newman, 1977):

- it is absolutely necessary to improve bio-statistical data collection system, which would enable the observation of any possible changes in the stock;
- there are grounds for believing that catches may remain at a level of 100 000 - 150 000 tons until additional information is obtained.

The above conclusions have not lost their relevance and could now be treated as recommendations.

2.9.4.2 Trachurus trachurus - Namibian stock

Estimations based on various methods and models have been made for the Namibian stock. For the conditions prevailing until 1979, the maximum sustainable yield was estimated at 410 000 - 520 000 tons (ICSEAF, 1979). It was pointed out in 1980 that despite the relatively high and ever-increasing total fishing effort, total catch and catch per representative unit of effort did not decrease but was on the increase (Wysokiński, 1981). This fact made it impossible to use production models for stock assessment and also revealed that the productivity of the stock is much higher. In the case of positive correlation between representative fishing effort and the density index, it may be believed that the present level of exploitation is lower than the maximum one even to about 25-30% (Wysokiński, 1981, after Ricker, 1975). For the situation directly before 1981, the Graham curve suggested that the MSY may equal 620 000 tons, which was confirmed by later estimations by means of other methods (Shcherbich and Florinskaya, 1982; Kolarov and Prodanov, 1983).

It is worth emphasizing the relatively high biological vitality of the species and its reproductive ability. Despite the above-mentioned high rate of exploitation, resulting in the reduction of age groups and mean length in the catch, the stock was able to react not only by the growth in recruitment, but also by the lowering of the length of first sexual maturity by 3 cm, as mentioned earlier.

From 1981 until the present, the situation of the stock is analysed annually in two stages: firstly, by experts from countries with a centrally-planned economy prior to the December sessions of ICSEAF, and again, at the session itself, with representatives of all countries present.

These estimates conform to a certain pattern (Babayan et al., 1985a) and are based on the following:

- analysis of the virtual population (VPA) on the basis of the number of fish in age groups, caught by the countries most seriously engaged in the horse mackerel fishery (Bulgaria, German Democratic Republic, Poland, Rumania and the USSR);
- regression of the historical series of total effort expressed in days fished of standard Polish trawlers (B-29) and fishing mortality coefficient F obtained from the VPA (at $M = 0.4$). This method makes it also possible to estimate terminal fishing mortality F_t, with the assumed partial recruitment of 40% in age group 2, 80% in age group 3, and 100% in age group 4 and older.
- analysis of yield per 1 year old recruit which would allow for the determination of the optimum exploitation at a level of $F_{0.1}$ and the corresponding catch;
- forecasting the total allowable catch in the next year and its impact on the status of the biomass, in various options related to the assumed exploitation rate and recruitment level.

The results of stock assessment for the situation existing until 1983-1984 are presented in Table 25 and Fig.18 (ICSEAF, 1985a). It appears from these data that stock biomass was at a low level in the years preceding 1970. From 1970, its steady increase was observed, from 900 000 to 1 800 000 tons in 1976. It remained at this level until 1979, followed by a sudden increase in 1980 to 2 700 000 tons. Without greater changes, the biomass remained at this high level until 1983, last of the analysed years.

Table 25

Trends of some more important parameters of Namibian horse mackerel stock, 1966-1983

Year	Total catch x 10^3 ton	c.p.u.e. (Polish data) t/d	Biomass B_{2+3} x 10^3 ton	Recruitment (R_1) x 10^6 fish		F_{2-6}	Total effort in days (Polish umt)
				in catch	from VPA		
1966	99.6		912		3 057	0.033	
1967	72.4		867		1 951	0.089	
1968	69.2		845		1 729	0.035	
1969	46.5		805		4 106	0.041	
1970	50.4		917	17	4 396	0.041	
1971	214.5		1 057	821	6 486	0.112	
1972	72.2	42.5	1.156	73	5 439	0.049	1 704
1973	271.4	48.3	1 350	37	7 318	0.242	5 619
1974	193.1	27.8	1 451	90	7 978	0.136	6 946
1975	242.2	37.2	1 680	21	6 224	0.079	6 511
1976	456.2	37.4	1 839	52	8 190	0.391	12 199
1977	352.1	30.2	1 717	1922	12 019	0.257	11 659
1978	516.2	39.8	1 827	147	13 764	0.489	12 970
1979	401.6	40.6	1 972	693	20 953	0.280	9 892
1980	544.1	42.8	2 736	92	23 291	0.488	12 713
1981	590.5	46.8	2 674	103	18 198	0.354	12 618
1982	660.0	47.1	2 850	137	15 415	0.481	14 013
1983	606.0	44.3	2 708	276	15 976	0.340	13 682
1984	530.0 1/	43.0 1/					12 325 1/

1/ Estimated

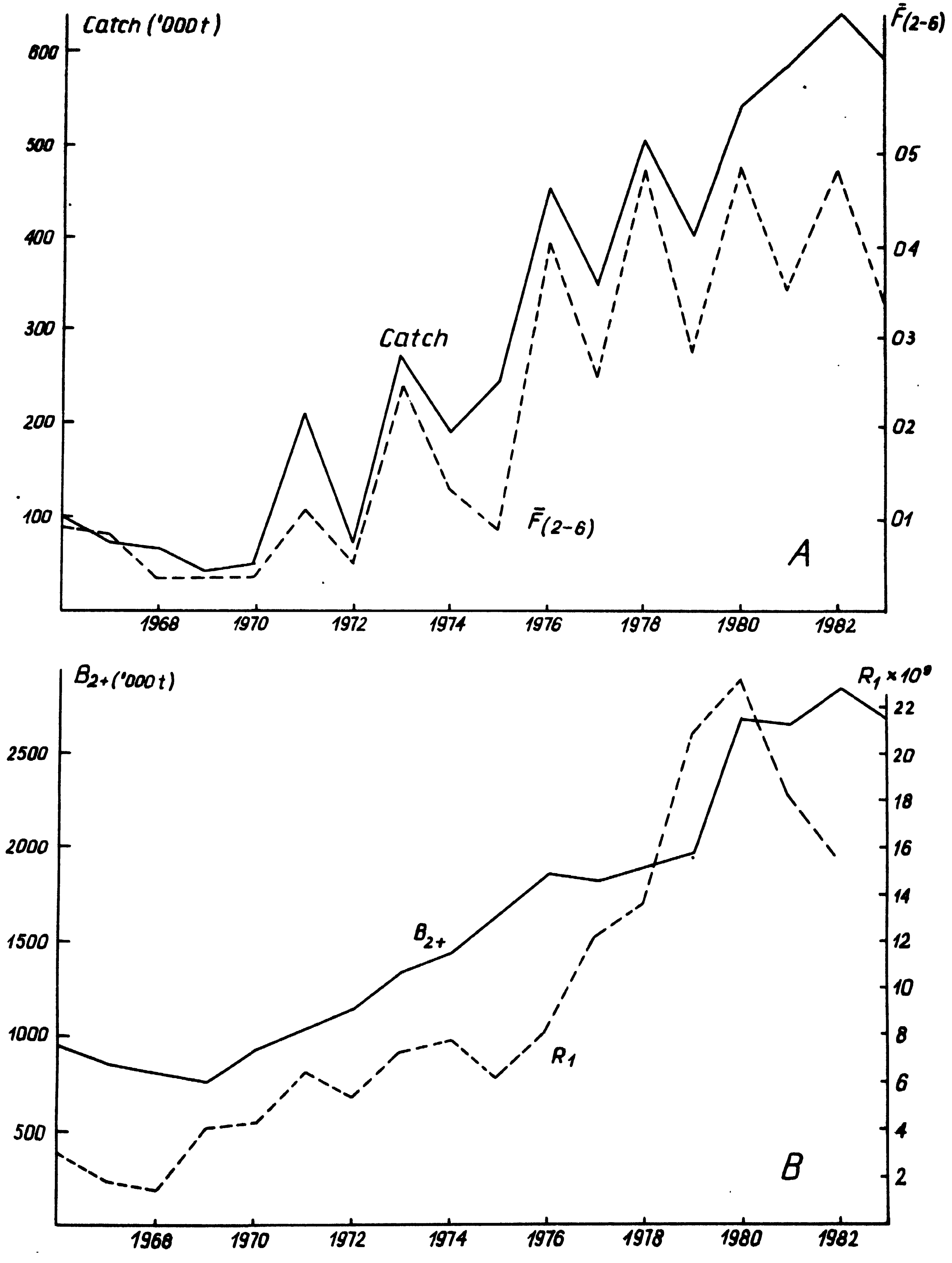

FIG.18 Cape horse mackerel in Divisions 1.3 + 1.4 + 1.5: trends in total catch, fishing mortality (A) and stock biomass and recruitment (B) in 1966-1983

A similar increase may be observed in recruitment. It began to increase from 4 thousand million specimens (R_1) before 1970 to a maximum level of 23 thousand million in 1980. Between 1981 and 1983, it remained at a slightly lower level of 18 thousand million fish in age group 1.

It may be concluded on the basis of the yield per 1 year old recruit curve drawn for the situation in 1983, at M = 0.4, that the exploitation of the stock was recently conducted in an optimum manner. The optimum exploitation, at a level of $F_{0.1}$ for age groups 2-6 should equal 0.35, which corresponds with the actual fishing mortality obtained from VPA. The sustainable, long-term catch at a level of $F_{0.1}$ and average recruitment of 1 year olds equalling 16 x 10^9, obtained from this analysis equals 590 000 tons (Babayan *et al.*, 1985a).

The total allowable catch for 1985 was estimated at a higher level of 630 000 tons because the fishing mortality in the previous year was lower than $0.35/F_{84} = 0.29$). The value of TAC for 1985 makes it possible to maintain the biomass at an unchanged level (ICSEAF, 1985a). The expected catch for 1985 depending on the assumed level of exploitation and the resulting level of biomass at the beginning of 1986 are outlined in Fig.19.

The above recent estimates have a serious drawback in that the only exploitation pattern used was that taking place on international fishing grounds, outside the coastal zone of 13.5 miles. These estimates do not take into account, due to the lack of information, the unexpected but significant share of juvenile horse mackerel in the coastal purse seine fishery.

These catches were insignificant until 1981 and only once, in 1971, they unexpectedly rose to 140 000 tons. However, in 1982, they equalled 67 000 tons, in 1983 104 000 tons, and in 1984, between January and September, 87 600 tons (Table 5). As mentioned in the previous section, the purse seines with mesh size of 11 mm harvest the juveniles of horse mackerel whose mean length is about 10 cm. These catches may substantially reduce the level of recruitment and cause a shift of the position of $F_{0.1}$ to the left on the yield per recruit curve and, as a consequence, a decline in the corresponding allowable catch (ICSEAF, 1985a).

It should be emphasized that in a similar period after the high catch of young fish in 1971, a considerable drop of both total horse mackerel catch in 1972 and catch per day fished by a Polish standard trawler occurred in subsequent years (Table 25).

Thus, there are grounds to believe that ignoring further the reduction in recruitment by the purse seine fishery may not only be harmful to the horse mackerel stock itself but also result in economic losses, especially for countries engaged in the trawler fishery directed at this species.

2.9.4.3 *Trachurus trachurus capensis* - South African stock

Most likely, horse mackerel inhabiting Division 1.6 and Agulhas Bank (Divisions 2.1 + 2.2), if not belonging to one stock are nevertheless closely related one to another by the fact of close location of these divisions, and the location of spawning grounds in the boundary area (Fig.20). Unfortunately there is no information on the migrations of horse mackerel in this area. The scientific expedition of the Polish research vessel "Professor Siedlecki" in May 1975 discovered relatively large resources of horse mackerel in Divisions 2.1 and 2.2; they consisted exclusively of older fish, with lengths of 25-53 cm (Morski Instytut Rybacki, 1975). This would suggest that horse mackerel does not spawn in these divisions.

Stock assessment was based on the swept area method in Divisions 2.1 and 2.2 and using the VPA with respect to horse mackerel caught by purse seiners in Division 1.6.

Joint scientific expeditions of Japan and the Republic of South Africa carried out in 1980-1982 on Agulhas Bank discovered that the biomass of the horse mackerel stock occurring to a depth of 100 fathoms and from the boundary of territorial waters was the following (Uozomi and Augustyn, 1983):

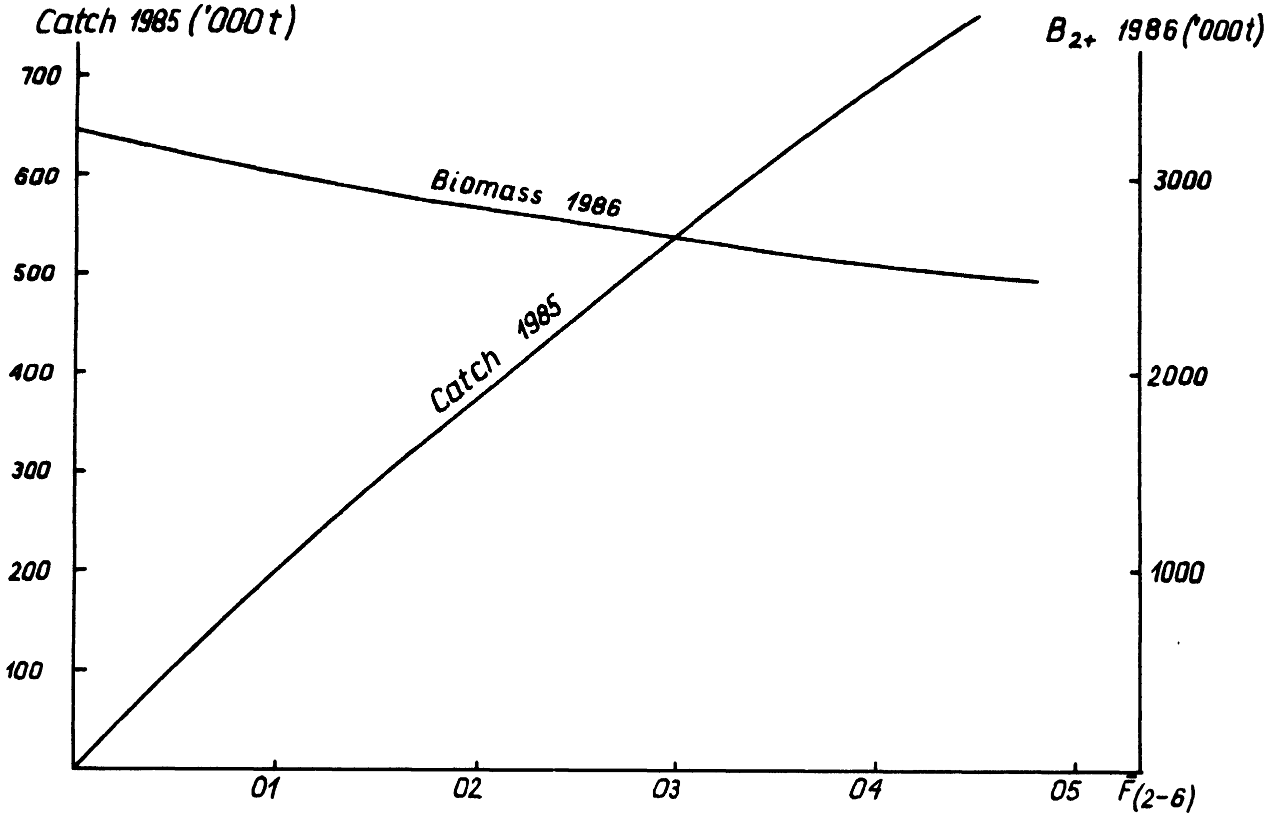

FIG.19 Cape horse mackerel in Divisions 1.3 + 1.4 + 1.5: projection of catch 1985 and biomass 1986 for different levels of fishing mortality in 1985 (ICSEAF, 1985a)

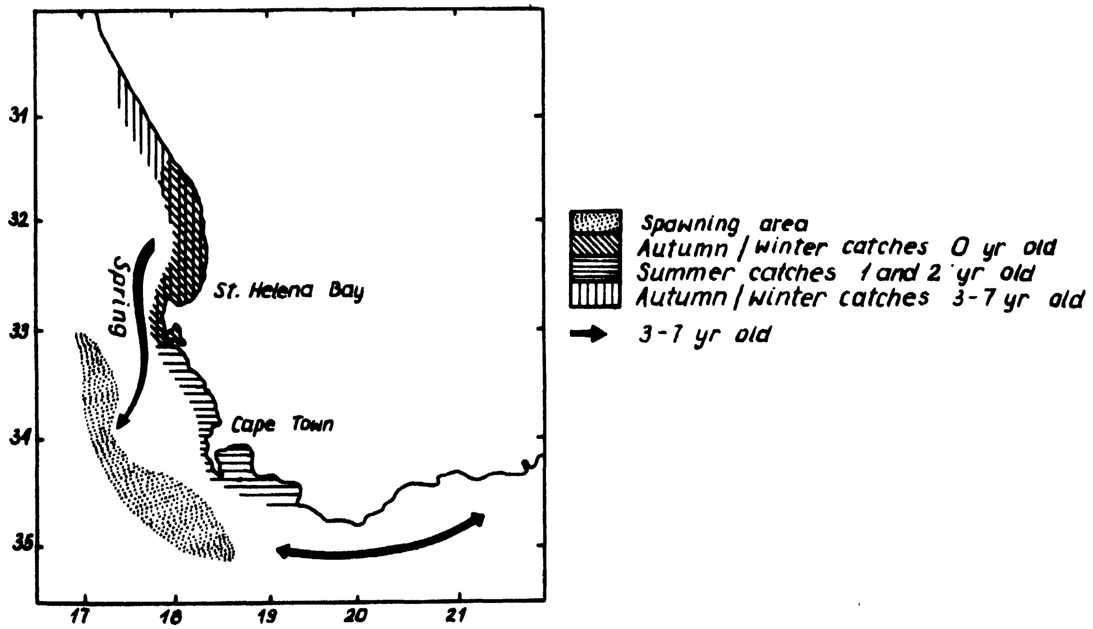
31
32
33
34
35
17
18
19
20
21
Spring
St. Helena Bay
Cape Town
Spawning area
Autumn / winter catches 0 yr old
Summer catches 1 and 2 yr old
Autumn / winter catches 3-7 yr old
3-7 yr old

FIG.20 Main spawning area, migration and catch locations for the different age components of the Cape horse mackerel stock in Divisions 1.6 + 2.1 + 2.2 (Davies et al., 1981, modified)

Summer 1980	90 000 ± 44 000 tons
Summer 1981	113 000 ± 21 000 tons
Winter 1982	107 000 ± 21 000 tons

Thus, the average level of the biomass in the investigated area amounted to 103 000 tons. In the corresponding period 1979-1982, the average annual catch in Divisions 2.1 + 2.2 was about 38 000 tons. It appears from the relation $F = C/B$ that fishing mortality at that time amounted to approximately 0.38, i.e., close to the level of natural mortality $M = 0.4$, assumed for horse mackerel in the whole area of its occurrence.

The above indices would justify a preliminary conclusion that the stock inhabiting Agulhas Bank in the early 1980's is close to the level of the maximum sustainable yield, or is, perhaps, slightly below it.

On the other hand, if the Agulhas stock was considered together with the stock in Division 1.6, there would be evidence contradicting the above conclusion. The stock in Division 1.6 for a number of years has been subjected to heavy exploitation by the multispecies purse seine fishery since 1964, using a minimum mesh size of 12.7 mm. On the basis of the data presented in Table 26, one could say that the stock is in a very poor condition, bordering on its total extinction. However, these data do not take into account trawl catches usually made at a greater distance from the shore, but concerning the same stock. For example, the greatest catch in Divisions 1.6 + 2.1 + 2.2 amounted to 116 000 tons (Table 23), including 23 000 tons in Division 1.6 and 93 000 tons on Agulhas Bank. That same year, purse seiners caught only 1 900 tons in Division 1.6. Thus, the estimate of stock parameters made by Davies et al. (1981) and presented in Table 26 is unreliable although it points out to the harmful impact of purse seine fishing with a mesh size of 12.7 mm on the stock.

Looking for more indices which could characterize the state of the stock in the whole area of its occurrence, catch results of Japanese trawlers operating in Divisions 1.6 + 2.1 + 2.2 in the years 1975-1983, directed at horse mackerel, were analysed (Table 27). It appears from those data that a general long-term downward trend of all indices occurred - catch, fishing effort, and catch per unit of effort, the latter being very small when compared with the c.p.u.e. attained on Namibian fishing grounds. However, the use of the production model based on the above data for the estimation of maximum sustainable yield is not possible because of the low correlation coefficient for c.p.u.e. in a function of fishing effort.

Thus, although the potential catch of horse mackerel in Divisions 1.6 + 2.1 + 2.2 could be of the order of 100 000 tons, as suggested by Newman (1977), if the exploitation of this area were based on rational grounds, the present potential is difficult to assess as a considerable portion of the juvenile stock had been constantly eliminated in the past, although lately juveniles have only been affected by incidental by-catching.

On the basis of a series of data concerning the size of actual catch remaining at the same level for several years (Table 23), it seems that the sustainable yield at a level of 30 000 - 40 000 tons could now be quite acceptable.

2.10 Sardinellas

There are two species of sardinella in the ICSEAF Area: Sardinella aurita and S. eba. Both inhabit coastal waters of Angola; not recorded separately in catch statistics because of similar appearance, they nevertheless differ by a number of biological parameters and environmental requirements.

2.10.1 S. aurita

It occurs on the shelf of West Africa from the Mediterranean Sea to Cape Frio in the southern hemisphere. Among three stocks inhabiting the shelf of West Africa, one inhabits the area from southern Gabon (0°) to the northern coast of Namibia (19°S), undertaking seasonal migrations along the coast (Fig.21). This species prefers warm waters with a temperature close to 24°C and a salinity of 35%, calm, but frequented by

Table 26

Some parameters on the horse mackerel stock in Division 1.6, 1954-1981 (Davies *et al.*, 1981)

Year	Catch '000 ton	Biomass '000 ton	Recruitment x 10^6	Age Range	Dominant
1954	118.1	4 170	635	2-12	5-8
1958	56.4	3 990	353	2-12	6-11
1960	62.9	3 200	504	1-12	4-7
1962	66.7	504	404	2-12	4-8
1964	24.4	84	86	2-8	3-5
1966	26.3	43	247	0-10	0-5
1968	1.4	0.6	114	0-2	0
1970	7.9	4.3	716	0-2	0
1971	2.2	2.4	64	0-5	0
1972	1.3	3.1	16	2-5	3-4
1973	1.6	2.6	89	0-7	0
1974	2.5	1.2	219	0-2	0
1975	1.6	1.2	189	0-2	0
1976	0.4	2.1	83	0-5	0-1
1977	1.9	4.2	206	0-5	0-2
1978	3.6	3.3	519	0-2	0-1
1979	4.3	2.9	69	0-2	0-1
1980	0.4	0.1	15	0-2	0-1
1981	6.1				

Table 27

Horse mackerel in Divisions 1.6 + 2.1 + 2.2
Catch and corresponding effort of Japanese trawlers, tonnage group 8
(after Sato, 1982; ICSEAF Stat.Bull.Nos 11-12; ICSEAF, 1984c)

Year	C (tons)	f hours fished	c.p.u.e. t/h
1975	30 675	23 509	1.30
1976	20 760	15 667	1.33
1977	22 473	17 105	1.31
1978	13 746	17 145	0.80
1979	15 229	20 530	0.74
1980	14 809	15 628	0.95
1981	15 037	15 061	1.00
1982	7 105	9 056	0.78
1983	5 763	5 991	0.96

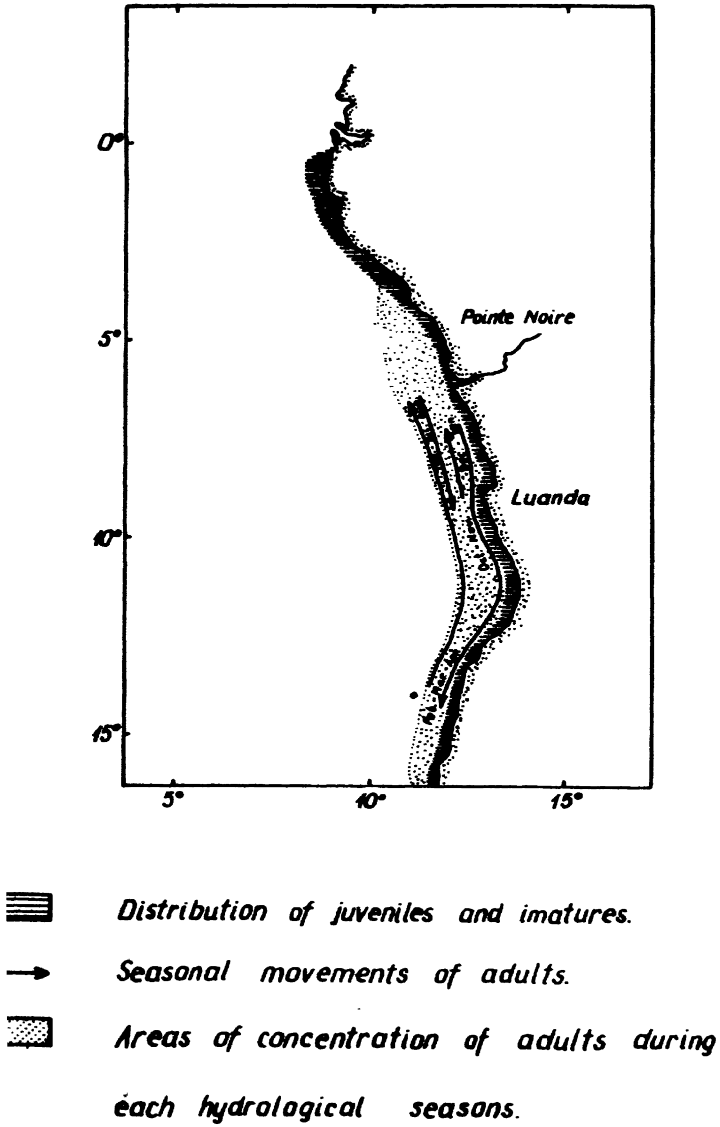
0°
5°
10°
15°
5°
10°
15°
Pointe Noire
Luanda
Distribution of juveniles and imatures.
Seasonal movements of adults.
Areas of concentration of adults during each hydrological seasons.

FIG.21 Distribution and seasonal migrations of Sardinella aurita off the coasts of Angola and Gabon (after Gheno and Campos Rosado in Troadec and Garcia, 1980)

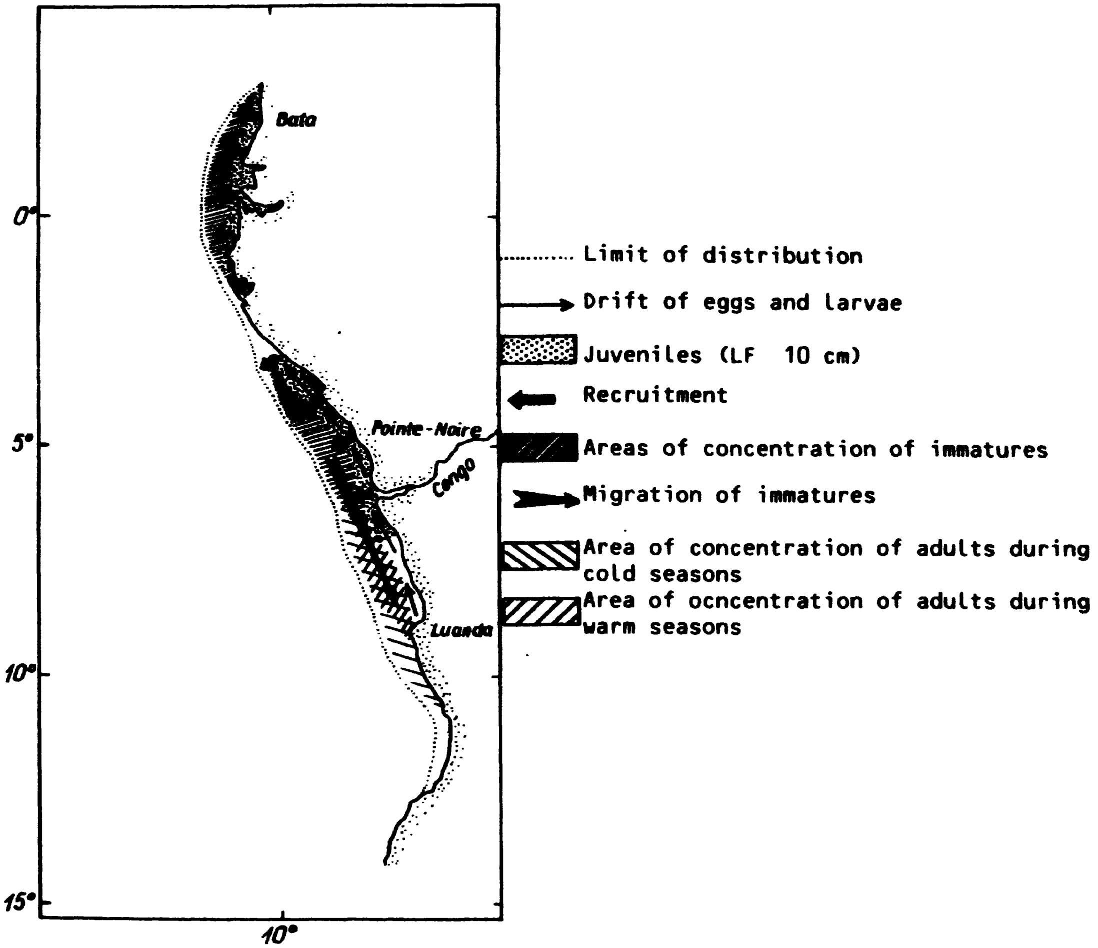

FIG.22 Distribution and seasonal migrations of Sardinella eba off the coasts of Gabon and northern Angola (after Gheno and Campos Rosado in Troadec and Garcia, 1980)

upwelling. A greater activity of the Angola current, with which the species is connected, may cause seasonal (March-May) migration of single schools as far as the waters off central Namibia, as was observed in 1983 (Thomas, 1984a).

As is the case with other clupeid fishes, in S. aurita a separation of the adult stock consisting of sexually mature fish from the stock of juvenile fish is observed.

Juvenile forms of S. aurita may be encountered in the whole littoral zone from Cape Lopez (Gabon) to the Tiger Bay (southern Angola). Upon reaching a length of 10-14 cm, juveniles leave the littoral zone and remain for some time in shallower shelf waters; upon attaining sexual maturity, they join the adult stock (Troadec and Garcia, 1980).

Recruitment to the exploited stock begins in fish with a length of 14-17 cm, age 1-2 years; its peak corresponds to a length of 23-25 cm. Specimens with lengths of 33-35 cm, age 5+ are in practice eliminated from the adult stock (Shcherbich, 1981a).

The migrations of the Angolan stock result in the seasonality of fishing on individual sectors of the coast. They have the following characteristics (Baptista, 1977):

Season Water Area	February	March-April	May-June	July-August	September-October	November	December-January
North of Zaire	weak	weak	increasing	highest	good	good	average
Northern Angola	good	highest	good	weak	increasing	good	weak
Central Angola	highest	good	decreasing	weak	increasing	good	weak
Southern Angola	average	average	weak	weak	increasing	average	weak

As may be seen from this list, the best fishing season off the coast of Angola is in February-June and September-November. In the remaining period, a part of the stock migrates beyond the ICSEAF Area, falling under the jurisdiction of coastal states, members of the FAO/CECAF Committee.

The stock of S. aurita is characterized by a large natural fluctuation in the abundance of individual year classes, which has a considerable impact on its size and age structure.

The parameters of the growth equation of S. aurita, based on scarce material of Shcherbich (1981, 1981a) are the following:

L_{∞} = 43.3 cm (body length); K = 0.28 t_o = -0.4

W_{∞} = 361.5 g. This author proposes to assume a relatively high natural mortality

M = 0.98 and an optimum age of first capture at a level of t_p = 2 years (20 cm body length).

2.10.2 S. eba

This species inhabits the coastal waters from Mayumba (3°30'S) to Lobito (13°S), preferring warmer waters (above 24°C); it is an euryhalic species, often occurring in estuarine areas. It is also a very coastal species, practically not found outside the belt of territorial waters; its migrations are not as extensive as those of S. aurita.

The distribution and seasonal migrations of this species are presented in Fig.22. It is suggested that the Angolan stock of S. eba is independent of the stock off the Gabon coast.

Age and growth rates, as well as age structure of the exploited stock, are not known. However, S. eba reaches smaller dimensions than S. aurita; off Congo and northern Angola fish with lengths of 14-20 cm predominate in the catch.

2.10.3 Catches and resources of sardinella

The first data on sardinella catches off the coast of Angola come from 1956. In the years 1956-1971, mean annual catches of sardinella and pilchard, recorded in statistics under one name "sardinha" were about 100 000 tons. It was estimated that this figure comprised 70 000 tons of sardinella and 30 000 tons of pilchard (Campos Rosado, 1974). In 1972, catches of Angolan sardinella, mainly in Divisions 1.1 and 1.2 made by 360 purse seiners were estimated at a level of 140 000 tons (Troadec and Garcia, 1980). The sardinella fishery was based, until the independence of Angola, on small, wooden, and ill-equipped purse seiners with a length of 20-25 m and 100-200 HP engines, supplying the fish to a small meal plant. There are no reliable data from the period of independence of Angola, but because of the stoppage of fish meal production and the suspension of fishing operations by certain companies (mainly Portuguese), the size of catch dropped in the years 1974-1976 to about 20 000 tons.

In 1977, the Soviet purse seiner fleet, mostly in tonnage classes 5 and 6 (150-1000 GRT) began intensive exploitation of the stock. Catch results in the first years, after independence and after the period of a significant reduction of fishing effort, were very good. In 1977, a record-breaking catch of 240 000 tons was made. However, in the years 1981-1983, the total catch remained at a slightly lower level of 150 000 - 180 000 tons (Table 28).

Besides the USSR, sardinella is caught by Angola and sporadically by Cuba, the German Democratic Republic, and the Republic of South Africa, the latter insignificantly in Division 1.3 south of the Cunene river estuary.

The estimation of stock productivity based on the data concerning catch and fleet tonnage (GRT) in the years 1960-1972 included a suggestion that the increase in catch was not accompanied by increased fishing effort; it was thus hard to believe that even when catch approached 100 000 tons overfishing of the stock was possible (Newman, 1977).

For the years 1977-1983, there is information on catch and fishing effort of Soviet purse seiners (tonnage group 6), operating in Divisions 1.1 and 1.2, as may be seen in Table 29).

With the help of the simple production models of Schaefer and Gulland-Fox, a high correlation r = 0.81 between mean 2-year fishing effort in Divisions 1.1 + 1.2 and c.p.u.e. was obtained. The maximum sustainable yield was, for both methods, 152 000 and 154 000 tons, respectively, with the corresponding effort equalling 9 500 and 10 000 days fished (Fig.23). Assuming, after Table 28, that sardinella catches in Division 1.3 constituted in the past three years about 10% of the total catch of this species, it may be assumed that the MSY for the whole area will increase approximately by the same percentage, amounting to not more than 170 000 tons.

As may be seen from the statistics, effective catch of sardinella remains now at a level of the maximum production capacity of the stock; therefore, further increase in the exploitation rate should not be recommended.

The above conclusion is based only on the analysis of catch and effort statistics and should be treated as preliminary. Further investigations of age structure and mortality distribution, which would enable a correction of the MSY so that it would reflect more accurately the present status of the stock, should be conducted on a wider scale.

Table 28

Sardinella catches off Angola (Divisions 1.1, 1.2 and 1.3 in the years 1977-1983 in '000 tons (ICSEAF Stat.Bull.Nos. 7-12 and ICSEAF, 1984c))

Year	Statistical Divisions			Total	USSR only	
	1.1	1.2	1.3		'000 tons	%
1977	8.9	41.4	84.2	134.5	85.6	63.6
1978	75.2	129.9	35.7	240.8	194.5	80.8
1979	91.0	74.6	39.0	204.6	180.1	88.0
1980	67.1	62.9	75.4	205.4	182.6	88.9
1981	67.5	74.9	18.0	160.4	111.0	69.2
1982	70.3	89.5	21.5	181.3	153.7	84.8
1983	52.7	88.2	12.8	153.7	124.7	81.1

Table 29

C.p.u.e. of Soviet PS-6 purse seiners in the *Sardinella* fishery and total fishing effort in Divisions 1.1 and 1.2 in 1977-1983 (ICSEAF Stat.Bull.Nos. 7-12 and ICSEAF, 1984c)

Year	Catch per day in tons			Total catch in '000 t Div. 1.1 + 1.2	Calculated effort in days
	Div. 1.1	Div. 1.2	Div. 1.1 + 1.2		
1977	16.8	14.6	15.9	50.3	3 164
1978	20.5	21.5	21.0	205.1	9 767
1979	12.9	18.8	14.8	165.6	11 189
1980	14.6	14.7	14.6	130.0	8 904
1981	13.3	12.9	13.1	142.4	10 870
1982	19.0	20.0	19.5	159.8	8 195
1983	16.6	22.4	19.4	140.9	7 263

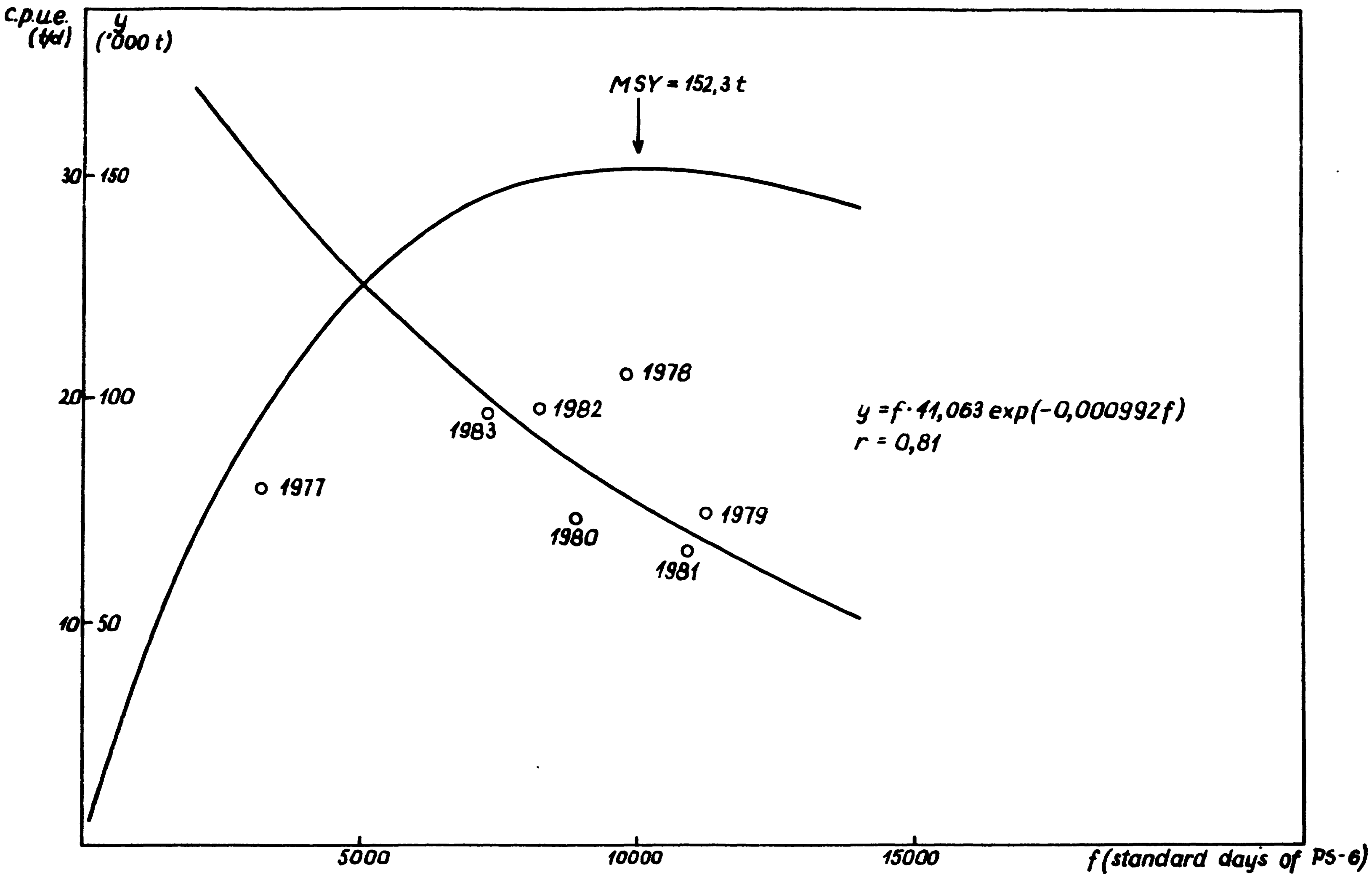

FIG.23 General production model for Sardinella aurita stock in Divisions 1.1 + 1.2 based on catch statistics and effort of Soviet purse seiners in 1977-1983

Nevertheless, the MSY at a level of 170 000 tons seems realistic enough in the light of suggestions by Troadec and Garcia (1980) that the potential catch of sardinella between southern Gabon and southern Angola may be at a level slightly exceeding 150 000 tons.

A more difficult problem in sardinella stock management is the determination of the size of catch quotas which should be negotiated between the governments of coastal states, with the distribution of the biomass, spawning grounds and areas inhabited by juvenile forms taken into account.

2.11 Pilchard (Sardinops ocellata)

In the ICSEAF Area, pilchard occurs from the Tiger Bay in southern Angola along the coast of Namibia and the Republic of South Africa, including Agulhas Bank, and farther to Durban, off the southeastern coast of Africa (Fig.24).

Pilchard is a typical shoal-forming pelagic fish; it feeds on plankton and undertakes feeding and spawning migrations along the coast as well as to and from the shore. The maximum range of its occurrence from the coast is 100 miles (Komarov and Kudersky, 1963).

Since its area of occurrence is so extensive (the shoreline has a length of 3 500 miles, 2 000 miles in a straight line), two main areas of pilchard concentration may be distinguished: statistical Division 1.4 with the Walvis Bay and Division 1.6 with St. Helena Bay. It appears from tagging experiments that two separate stocks inhabit these areas (Newman, 1977). They are separated by Division 1.5 with relatively lower primary production. The life cycle of both stocks is similar. Abundant feeding concentrations may be observed from March till August in the shallow waters of both the above-mentioned bays and in their vicinity. Besides, pilchard concentrations are observed in Tiger Bay from June till October, as well as in January. It is very likely that pilchard from this bay and Division 1.3 form a separate stock. On the southeastern coast of Africa, shoals of young pilchard migrate from Division 1.6 northeastward along the coast of Natal, reaching Durban. They remain there through June-July and return south, taking a more oceanic route (Komarov and Kudersky, 1963; Crawford and de Villiers, 1984).

Beginning with June-July, main concentrations of adult fish in Divisions 1.4 and 1.6 begin their spawning migration from shallow coastal waters towards warmer waters of the open ocean. They do not leave the coast suddenly and in great numbers, but continue to migrate until November. The appearance of the adult stock on the fishing grounds of Namibia (outside the coastal zone of 13.5 miles) is observed from June with a peak in July-September; in November these stocks disappear. Within this period, pilchard shoals scatter over an extensive area. Fish with maturing gonads may be encountered from the mouth of the Orange river to 21°E on Agulhas Bank; in the north - from Lüderitz to the northern boundaries of the species distribution. Spawning usually takes place over the shelf and slope, not deeper than 200 m, but not closer to the shore than 8-10 miles. It occurs in batches and is extended in time. Mean, individual fecundity of the species is about 95 000 eggs (Komarov and Kudersky, 1963). Eggs and larvae may undergo passive migrations, driven by sea currents while the later development of juvenile stages takes place in the near-shore zone.

There is a controversy surrounding the issue when pilchard reaches first sexual maturity. This species usually attains maturity at the age of 4, at a total length of 22 cm (Baird, 1970). Soviet sources determine this age at 3-4 years (Komarov and Kudersky, 1963). Polish investigations carried out in August and September 1974 and 1975 at latitudes of 18-23°S in a depth range of 100-130 m confirm Baird's findings. Mean length of males with 50% maturity was 21 cm, with mature individuals of the smallest size of 19.5 cm. For females, these lengths were 23 and 21 cm, respectively. These lengths correspond with the age of 3-4 years for males and 4-5 years for females (Wysokiński and Krakus, 1977).

On the other hand, according to the latest determination of stock parameters made by the Republic of South Africa, spawning stock begins with age 1+ (!), with an assumption that mean length at 50% first maturity is 18.4 cm[1] (Armstrong et al., 1983). However,

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[1] All lengths of fish have been converted to total length adapted by ICSEAF. The calculations were based on the formula $L_c = 0.8357\ L_t + 0.097$ (Thomas, 1979 after Newman).

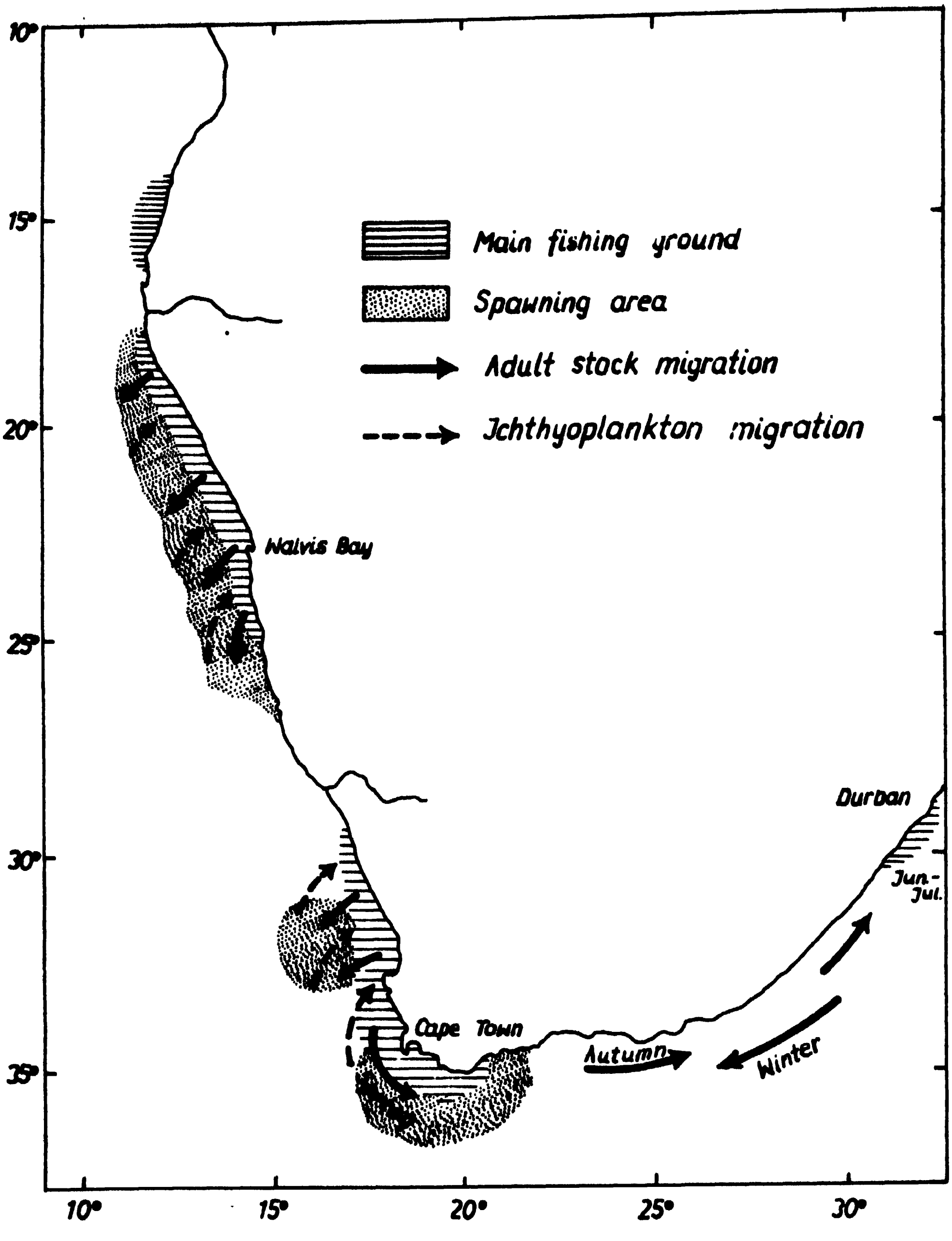

FIG.24 Distribution, migrations, and fishing grounds of pilchard in the ICSEAF Area

the same authors admit that the share of age 5+ specimens in the stock considerably contributes to higher recruitment.

The growth rate of pilchard in the first year of life is high. Fish born at the peak of the spawning period (in September-October) reach a length of 8-12 cm in February-March next year while in May the greatest recruitment to the stock taken with 11 mm mesh purse seines is observed (Thomas and Bohme, 1981). In this period young pilchard mix in the shallow coastal waters with anchovy and are subject to heavy exploitation. After reaching a length of 15.5-16.5 cm, the stocks of both species probably undergo separation.

Growth parameters determined by several selected authors are the following:

	L_{∞}	K	t_0
Baird, 1970	30.6	0.22	-1.50
ICSEAF, 1974	30.8	0.32	-0.28
Wysokiński and Krakus, 1977	28.5	0.28	-1.42
Thomas, 1979	26.7	0.56	
Thomas, 1983	25.5-27.4	1.09-1.33	0.145-0.349

The method of determining age in days, used by the Republic of South Africa, confirmed the fast growth of fish in the first six months of their life (Thomas, 1979, 1984), which agrees with the parameters assumed earlier. However, for older fish the South African experts assumed parameters considerably departing from those determined by other authors. The catabolism coefficient (K) was determined by the former at an exceptionally high level (1.09-1.33) (Thomas, 1983), which may be referred to the juvenile period but not to the whole stock. Similarly, asymptotic length in the South African data (about 26 cm) is clearly underestimated in the light of the length composition observed in adult stock taken at a greater distance from the shore (Wysokiński and Krakus, 1977).

2.11.1 Fishery and state of the stocks

Pilchard catches in the ICSEAF Area in the past 25 years were subject to especially strong and drastic fluctuations (Table 30). The lowest catch off the coast of Namibia is over 100 times smaller than the highest catch. Within that time the fishery passed through three long-term stages: intensive development until 1968, regression which lasted until 1976, and stabilization at a very low level lasting until the present.

Crucial for the development of the purse seine fishery, as well as the state of pilchard stocks was, on the one hand, the development of fish meal on land and at sea (factory vessels) and, on the other, the diminished severity of catch regulatory measures.

In the years 1960-1962 the size of the total pilchard catch in the whole ICSEAF Area was 600 000 - 800 000 tons, half of which consisted of the Namibian stock (Divisions 1.3 + 1.4 + 1.5) and half of the South African stock (Divisions 1.6 + 2.1). Beginning with 1963, the catches in both areas took different paths.

Off the coast of Namibia, catches increased with the steady development of the purse seine fishery and land-based processing facilities from 300 000 - 400 000 tons in 1960-1962 to 700 000 tons in 1965. After the introduction of factory vessels with meal plants on board in 1966-1969, catches continued to rise to a maximum level of 1 400 000 tons in 1968 and 1 100 000 tons in 1969. At the same time, in 1968-1969, purse seiners with a mesh size reduced from 32 to 11 mm came into use in order to widen the species composition of catches (to include anchovy).

After this period of intensive exploitation, catches began to drop, first to 500 000 tons in 1970-1975, then to 260 000 tons in 1977, and finally to the lowest level of 12 000 tons in 1980. In 1981-1983, this downward trend was halted and catches remained at a level of 50 000 tons.

Table 30

Catch statistics of pilchard in the ICSEAF Area, 1960-1983

in'000 tons

Year	1.3 + 1.4 + 1.5					1.6	Total ICSEAF Area
	R.S.A.	Angola	USSR	Other	Total SBA 1	R.S.A.	
1960	284	10	-		294	318	612
1961	340	3	4		347	402	749
1962	395	8	6		409	410	819
1963	555	24	29		608	390	998
1964	682	2	79	1	764	256	1020
1965	727	-	111	3	841	204	1045
1966	801	1	52	4	858	118	976
1967	926	1	42	1	970	68	1038
1968	1387	2	10	2	1401	108	1509
1969	1110	6	4	1	1121	56	1177
1970	514	51	-	-	565	62	627
1971	325	2	1	-	328	88	416
1972	374	73	-	-	447	104	551
1973	408	23	1	-	432	69	501
1974	562	10	1	11	584	16	600
1975	561	7	-	9	577	89	666
1976	452	1	6	2	461	176	637
1977	200	-	53	13	266	58	324
1978	46	-	2	3	51	97	148
1979	34	-	3	5	42	53	95
1980	11	-	1	-	12	50	62
1981	52	-	1	0	53	46	99
1982	51	-	0	3	54	34	88
1983	44	-	1	5	50	61	111

Source: 1984; Newman 1977, Armstrong et al.,1983 and ICSEAF Stat. Bull. Nos 6-12 and ICSEAF, 1984c.

The change in mesh size was followed by a drop in the biomass of the southern stock and of the catch from 400 000 tons in 1963 to 100 000 tons in 1966. In the following years until 1983, the catches remained at the same level of 50 000 - 100 000 tons with the exception of 1974 when the lowest catch (16 000 tons) was recorded and 1976, when the catch reached a maximum for this period (176 000 tons).

Until 1983 pilchard was taken almost exclusively by purse seiners of the Republic of South Africa as part of the so-called multi-species pelagic fishery, in which fishing effort was not directed specifically at any of the species caught; at present the situation is similar but some new regulations concerning target species have been applied. The catches made by Angolan purse seiners are small, as may be seen in Table 30; since 1976 until the present, it does not report pilchard in its catches at all.

The quantitites of this species taken by trawl by other countries are also insignificant. Between 1980 and 1983 the USSR, Poland and other countries report pilchard as by-catch in the horse mackerel fishery caught mainly between July and September, amounting to 1 000 - 5 000 tons.

The nature of the purse seine fishery and the choice of regulatory measures with respect to pilchard had a substantial influence on the age structure of the fish landed. Its changes are presented on catch curves drawn for the South African stock in three periods corresponding to the dates of introduction of the permissible mesh size in purse seiners (Fig.25, Newman et al., 1978; Armstrong et al., 1983).

In the catches made in 1950-1955, when the minimum mesh size was 38 mm, pilchard were of age 1-8, with age group 5 predominating and fish age 4 and younger only partly recruited to the exploited stock. When the mesh size was reduced to 32 mm in 1956, the catch curve shifted to the left, with 3-4 year-olds predominating. When the mesh size of 12.7 mm was introduced in 1964 (used until the present), young pilchards of age 0 turned out to be fully recruited to the exploited stock. At the same time the share of juveniles in the total catch of pilchard increased to 60% in age group 0 and 90% in age groups 0 and 1. The stock grew younger with age group 6 becoming the oldest.

At that time the by-catch of Polish trawlers and other countries using 40 mm mesh, and since 1981 60 mm mesh, consisted quite exclusively of mature fish, age groups 2-7, with a predominance of 4-6 year-olds (Wysokiński and Krakus, 1977; ICSEAF Sampl.Bull. Nos.6-10; ICSEAF, 1983b; ICSEAF, 1984f). Since the size of pilchard trawl catches is small, its influence on the stock may be disregarded. On the other hand, the considerable reduction of young fish in the purse seine fishery, when the age of first sexual maturity in females is 4-5 years, may have had a negative impact on the size of the stock biomass.

The biomass of the Namibian stock, estimated for 3 year-olds and older by means of the virtual population analysis for the years 1964-1974 (Table 31), and confirmed by acoustic and aerial surveys equalled from 3 to 4 million tons, although as early as 1975, a downward trend was observed (a drop to 1-7 million tons (Newman, 1977)). On the basis of the data from the period before 1975 and the results of tagging experiments, Newman determined the approximate maximum sustainable yield of the Namibian stock at a level of 600 000 tons, although it is likely to fluctuate from 400 000 to 1 000 000 tons. At present the biomass of the stock dropped to a level of 150 000 tons.

The southern stock from Division 1.6 in the period when it was in a good condition (1950-1963) had a biomass (3+) of 600 000 to 1 500 000 tons, and 2 million in 1960. With the introduction of 12.7 mm mesh size in 1964, the biomass dropped, remaining in the years 1965-1978 at the average level of 250 000 tons. Thanks to high recruitment in 1979 the biomass in 1980-1981 increased rapidly to over 600 000 tons. However, catches made in 1980-1983 did not confirm the improvement in the state of the stock (Table 30).

A different series of data on the biomass of the spawning stock (B_{1+}), based on the VPA with modified age interpretation, was given by Armstrong et al. (1983). According to them, when unselective fishing gear for pilchard was allowed, its biomass began to drop from the maximum values of 500 000 - 600 000 tons in 1960-1962 to 60 000 tons in 1967, remaining at the same low level of 40 000 - 60 000 tons until 1980.

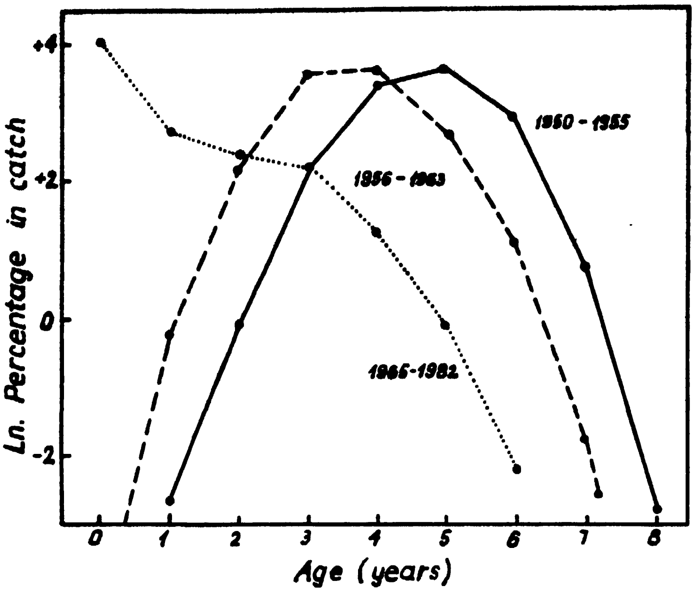

FIG.25 Catch curves for South African pilchard during the periods 1950-1955, 1956-1963 and 1965-1982 (Armstrong et al., 1983)

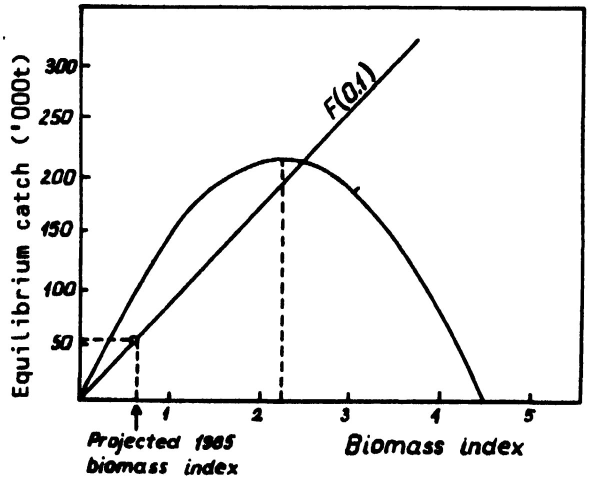

FIG.26 Anchovy off the Namibian coast: the Schaefer production model indicating the equilibrium catch at $F_{0.1}$ for 1981 (ICSEAF, 1984a)

Table 31

Biomass and recruitment of pilchard in the ICSEAF Area (from VPA)

Year	Div. 1.3 + 1.4 + 1.5				Div. 1.6 after Shelton, 1982	
	Stock in number (x 10^9) after Thomas, 1984 (from VPA)	Biomass in '000 t		Recruitment in number (x 10^9) (age group 0) (after Thomas, 1984)	Biomass in '000 t	Recruitment in number (x 10^9)
		(B_{3+}) (after Newman, 1977)	Total (after Thomas, 1984)			
1950					877	12,5
1954					640	9,7
1957					1520	41,6
1960					1940	18,5
1961					1690	16,2
1962					1360	10,5
1963					978	4,6
1964		2510			592	3,2
1965		3860			383	3,2
1966		4120			244	5,2
1967	63,7	4060	5955	14,8	260	10,3
1968	46,6	3760	4161	13,3	287	10,3
1969	30.9	2510	2402	11,2	241	6,2
1970	24,7	1530	1449	12,3	234	6,1
1971	28,0	2060	1376	16,7	252	8,9
1972	39,2	3100	1733	26,3	183	3,8
1973	37,8	2900	2114	18,2	181	8,8
1974	32,9	2440	2125	13,7	203	6,7
1975	19,9	1750	1582	5,5	277	6,1
1976	9,2		836	1,9	250	4,8
1977	4,5		315	1,8	185	6,1
1978	1,6		100	0,7	176	3,8
1979	0,7		49	0,3	387	31,6
1980	2,2		53	2,0	611	12,6
1981	4,0		150	3,0	660	1,2
1982	1,5		160-175	0,1		
1983	1,9		125-150	1,4		
1984			100-175			

Since the assumptions on which age calculations are based, especially the age of first sexual maturity, are not too reliable, biomass and recruitment estimates of Armstrong et al. (1983) and Shelton (1982) (Table 31) are not convincing. For this reason the estimate of Newman (1977) giving the maximum sustainable yield of the southern stock at a level of 100 000 tons with a possibility that it may periodically exceed this value, depending on the force of recruitment and exploitation pattern, seems to be the most reliable.

2.11.2 Fishery management

At present local authorities undertake drastic measures to prevent the total extinction of the stock. In Namibian waters these measures include the shortening of the fishing seasons to 15 March - 31 August, the reduction of catch quota to 35 000 tons for 1983 and 1984, a recommendation that pilchard be taken with a large mesh of 28 mm, temporary bans on fishing operations for anchovy, as the main target species, if the catches are found to include too great a portion of small pilchard. In recommending this, it is assumed that by-catch of pilchard recruits in a mixed fishery does not rise above 10 000 tons (Thomas and Boyd, 1985; South African Fishing Industry, 1985).

The management measures for the southern stock have also been improved. Instead of a constant quota for all pelagic species equalling 380 000 tons from 1977 until 1983, individual quotas for pilchard and anchovy have been introduced and for 1984 the limit of directed catch on pilchard was only 28 300 tons. In addition, since 1983 a new split-season policy allowed fishing between January and July and between October and December. Unfortunately, no quota was set on other commercial fish (non-quota species) such as chub mackerel or horse mackerel and their juveniles (Shelton, 1982; South African Fishing Industry, 1985).

The strategy based on total multi-species catch limits has serious drawbacks, two of which are worth mentioning here: it does not take into account the differences in species biology and technical advancements in the purse seine fishery.

The multi-species nature of the purse seine fishery, both in the north and the south, exists in the absence of a target species. Meanwhile, each of the species taken exhibits different fluctuations of recruitment, different biological parameters of the stock and, above all, different age of first sexual maturity, and each of them requires the use of a different exploitation pattern. The use of one common production curve for such different stocks cannot be a satisfactory solution, and the value of the curve itself is doubtful (Newman et al., 1978).

Advancements in fishing techniques and utilization of the raw material in the purse seine fishery of the Republic of South Africa is considerable. In the 1970's, hydraulic winches, blocks for hauling purse seine, pumps for fish manipulation, equipment for localizing fish concentrations from sea and air, and many others, were widely introduced. In the 1980's the wooden purse seiners of about 100 GRT have been gradually replaced by steel seiners of 150-300 GRT, equipped with cooling installations, which enable the vessels to remain at sea for a longer time (Newman et al., 1978; Armstrong et al., 1983). All these innovations make it more difficult to determine the representative series of data concerning the relationship between fishing effort and catch.

The problem of ineffective regulatory measures introduced by the Republic of South Africa regarding pilchard has been widely discussed by Glantz and Thompson (1981) as well as by Butterworth (1983). From the biological point of view it seems that, besides environmental conditions and excessive catches in the past, the direct and significant reason for such a large drop in pilchard abundance, bordering extinction, was the tolerance of 11 and 12.7 mm mesh size in the purse seine fishery. The experts of the Republic of South Africa were aware of this fact, justifying the decision concerning the use of small-meshed purse seines in the following way (Newman et al., 1978):

"The lowering of the minimum mesh size to 12.7 mm considerably reduced the age structures of the individual stocks (of pilchard), but had the advantage of broadening the species base of the fishery (anchovy, young chub and horse mackerel, etc.)." 1/

1/ The words between brackets have been added by the author.

Thus, the exploitation pattern introduced quite consciously has made stock reproduction impossible by capturing fish age 0 and 1 (about 90% of the total pilchard catch), eliminating all surpluses of recruits which may have appeared in periods of favourable environmental conditions. Therefore, besides environmental causes, the reason for the permanent low biomass observed for a number of years lies not in the excessive exploitation of the adult stock but in overfishing of juveniles. The latter cannot reach the age of reproduction and the optimum unit body weight cannot be attained by them.

The exploitation pattern for pilchard favoured the stock of anchovy, at least in Division 1.6 (12.7 mm mesh), and corresponded to its biological stock parameters. Anchovy with its short life-span and early spawning could, under these conditions, participate in the reproduction process in spite of heavy exploitation whose pattern - as will be discussed in later chapters - favours the attainment by the stock of its maximum production potential.

2.12 Anchovy (Engraulis capensis)

Anchovy is a typical shoal-forming fish, connected with the coastal zone; for this reason, it is exclusively taken by the coastal fishery. It occurs along the coast of Namibia and the Republic of South Africa to Cape Inflants on Agulhas Bank (20°45'E). As is the case with pilchard, two main stocks are distinguished: the Namibian one, inhabiting Divisions 1.3 + 1.4 + 1.5 and the South African stock in Divisions 1.6 and 2.1.

It is a short-lived fish which quickly reaches sexual maturity - thus, it does not attain great lengths. It begins spawning at the end of its first year of life, migrating to spawn in the zones with warmer water (Davies et al., 1981).

The biological parameters quoted by the above-mentioned authors are the following:

$L_{\infty} = 14{,}75$ cm L_c; $K = 0.45$, $t_o = -0.717$

$L_t = 1{,}1174\ L_c + 0.6017$; $W_t = 0.0034 L_t^{3{,}25}$

The exploitation of the stock began first off the coast of the Republic of South Africa after the introduction of 12.7 mm mesh size in purse seines in 1963. Exploitation off the coast of Namibia started shortly after, with an allowable mesh size of 11 mm.

Anchovy is exploited by seiners engaged in the multi-species pelagic fishing; its share in the catches reaches up to 80%, depending on the recruitment level. It is a major species in this kind of fishery, together with juvenile pilchard and horse mackerel and other species caught as by-catch (round herring, lanternfishes, pelagic Gobidae, snoek in the northern area, and additionally juvenile chub mackerel in the southern area).

Total anchovy catches in the ICSEAF Area in the 1980's fluctuate between 400 000 and 520 000 tons. The highest catch was recorded in 1973-1974 about 600 000 tons (Table 32).

Because of a clear geographical boundary of anchovy stock distribution, the assessment of the northern and southern stocks is made separately.

2.12.1 Namibian stock

The Namibian stock is almost exclusively exploited by the Republic of South Africa with a 2% share of the catch landed by Angola and the USSR. Total anchovy catches have exhibited large fluctuations in recent years and were generally characterized by a downward trend. The highest catch of 355 000 tons was observed in 1978, the lowest (13 000 tons) in 1984 (Table 32). This drastic drop in 1984 was caused by a sudden inflow of warm-water masses to the spawning areas in March 1984, which reduced about 20 times the production level of eggs as compared with the previous years (ICSEAF, 1984a).

The Namibian stock is exploited by the local purse seine fishery within a short period - from 1 May till 31 August - first on the more northern fishing grounds (18-20°S), later on the more southern ones (21-26°S). The stock migration routes have not been determined in detail.

The anchovy caught have a caudal length from 5 to 13.5 cm, their mean annual length ranges from 9 to 10 cm. The main component of the catch is fish at age 0, as illustrated below in the age composition of landings, in one thousand million specimens (ICSEAF, 1984a).

Table 32

Catch and biomass of anchovy in the ICSEAF Area

in '000 tons

Year	1.3 + 1.4 + 1.5					1.6 + 2.1		ICSEAF Convention Area	
	Catch				Biomass 5/ '000 t	Catch 2/ R.S.A.	Biomass 4/	Catch	Biomass
	R.S.A. 1/	Angola 2/	USSR 3/	Total					
1963	n.a.	n.a.	n.a.		n.a.	0		n.a.	n.a.
1964	..	..	..		.	92	310	..	..
1965	..	..	..		..	171	310	..	..
1966	..	..	..		..	144	290	..	..
1967	..	..	..		..	271	343	..	..
1968	161	..	..	161	2 172	138	250	299	2 422
1969	226	..	..	226	1 543	149	290	375	1 833
1970	189	.	..	189	906	169	323	358	1 229
1971	185	..	..	185	655	157	283	342	938
1972	137	10	..	147	646	236	260	383	906
1973	296	63	..	359	748	251	370	610	1 118
1974	249	-	..	249	572	350	460	599	1 032
1975	186	6	..	192	550	224	483	416	1 033
1976	88		..	88	503	218	500	306	1 033
1977	133	0	..	133	549	236	520	369	1 069
1978	355	2	6	363	728	210	550	573	1 278
1979	277	3	11	291	448	291	603	582	1 051
1980	190	0	20	210	402	316	512	526	914
1981	199	2	17	218	477	292	570	510	1 047
1982	84	1	2	87	293	307		394	
1983	184	1	2	187	481	240		427	
1984 6/	13			(13)	280				

1/ Le Clus, 1984 2/ Armstrong *et al.*, 1983 3/ ICSEAF Stat. Bull. Nos 8-12, ICSEAF, 1984c

4/ Shelton, 1982 5/ Le Clus and Melo, 1981, Le Clus, 1984 6/ ICSEAF, 1984a

n.a. = not available

Year / Age group	0	1	2	3
1972	10.5	1.5	1.0	0.11
1975	16.2	1.6	1.0	0.13
1978	29.5	3.8	1.9	0.18
1981	21.5	0.7	0.4	0.02
1982	4.2	1.2	1.2	0.12
1983	16.8	1.3	0.9	0.11
1984	0.6	0.3	0.1	0.01

The stock biomass exhibits a permanent downward trend in spite of the appearance of several strong year classes, which suggests that the stock has been overfished. The biomass estimate is made annually on the basis of the virtual population analysis, with the assumed natural mortality M = 0.8. Its size, remaining in the 1970's at the stabilized level of 400 000 - 700 000 tons, dropped to 280 000 tons in 1984 (Table 32).

The maximum equilibrium yield of the Namibian stock was estimated on the basis of catch statistics and biomass from the VPA by means of Schaefer's model (Le Clus and Melo, 1981), which analyses the following relationship:

$\frac{B + C}{B} = OC \, (B_{\infty} - B)$ where: B = biomass, C = catch, and OC = coefficient.

The maximum sustainable yield calculated in this way equals MSY = 200 000 tons when the optimum biomass level is 500 000 ± 95 000 tons. The stock condition expected in 1985 at $F_{0.1}$, with the long-term downward trend of the biomass taken into account, suggests the necessity to reduce the catch to 50 000 tons (Fig.26, ICSEAF, 1984a).

Long-term observations of the stock reveal a weak dependence of recruitment on the parent stock. Under favourable conditions a small parent stock is able to produce a large number of recruits; when environmental conditions are unfavourable, even a large stock of adult anchovy is not able to halt the reduction of recruitment (Le Clus, 1984).

In order to prevent further reduction of the size of the stock, the local authorities have implemented, in addition to lowering the catch limit to 200 000 tons in 1983 and to 50 000 tons in 1984, a shortening of the fishing season in 1984 to 1 June-31 August instead of 1 May-31 August (South African Fishing Industry, 1985).

2.12.2 South African stock

The life cycle of the stock is relatively well known. The adult stock is distributed over the coastal zone, south of 31°S to 19°30'E. In autumn, the stock migrates east of the Cape of Good Hope, where spawning takes place. The eggs and larvae are carried back north by the sea current (Fig.27).

The annual catch in the period 1979-1983 did not exhibit such great fluctuations as in the northern region, remaining at a level of 240 000 - 310 000 tons. The catches are part of a constant total limit for all species taken by about 90 seiners. This limit equals 380 000 tons per annum and is divided among 10 land-based fish processing plants (mainly fish meal plants).

The age composition of catches reveals that the highest fishing mortality covers age groups 0 and 1, as illustrated below by the number of fish caught by age in 1970-1981 (Shelton, 1982) in one thousand million specimens:

Year / Age group					
1970	24.6	4.5	0.8	0.2	0.03
1975	28.8	5.2	1.4	0.3	0.01
1980	17.7	9.0	1.3	0.2	0.00
1981	19.5	11.1	2.5	0.6	0.04

Long-term recruitment and biomass trends based on the VPA exhibits a permanent upward trend. The number of recruits increased from 33 thousand million in 1956 to 120 thousand million in 1981, and the biomass from 310 000 to 570 000 tons, respectively (Shelton, 1982). More cautious estimates point out that, within the same period, the number of recruits reaching six months of life increased two-fold from 25 to 50 thousand million fish and the biomass of the spawning stock B (1+) from 100 000 to 200 000 tons (Armstrong et al., 1983).

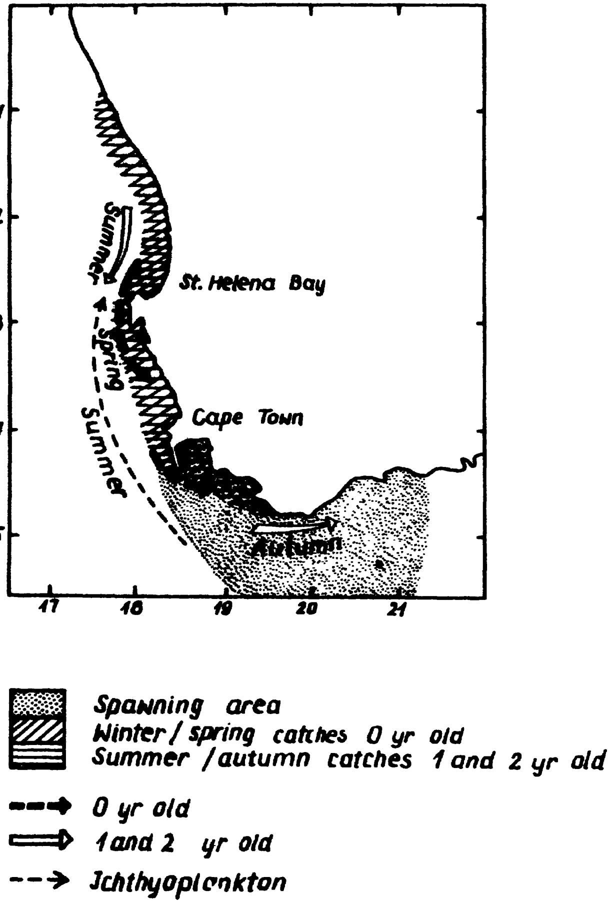

FIG.27 Main spawning area and catch locations for different components of the anchovy stock in Division 1.6 (Davis et al., 1981)

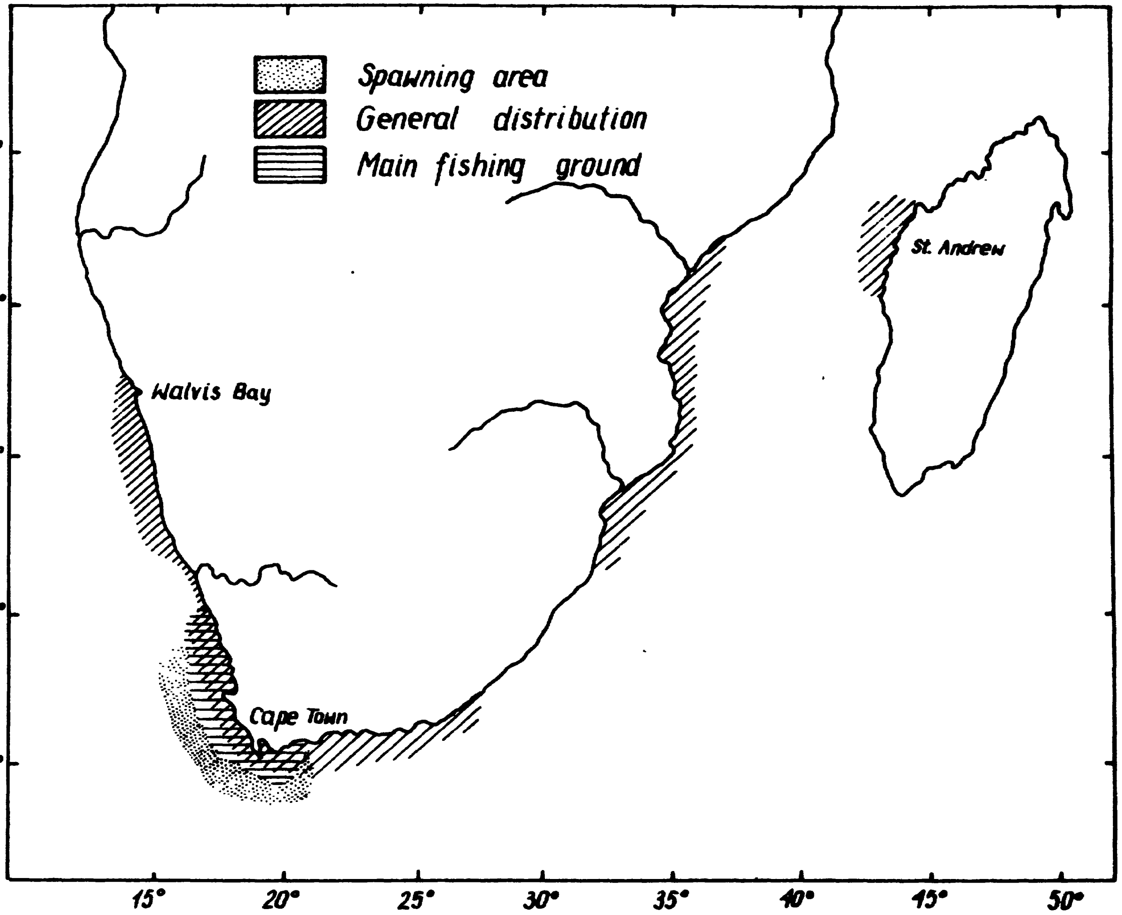

FIG.28 Distribution, spawning grounds and main fishing grounds of round herring in the ICSEAF Area

The maximum sustainable yield has not been clearly determined. The estimate made recently by Armstrong et al. (1983), and considered by its authors not too relianle, is based on the determination of yield per recruit with optimum fishing mortality $F = 0.5$, and natural mortality $M = 0.8$. According to them, it equals about 150 000 tons, assuming long-term mean recruitment. When confronted with a series of data about the real catch (Table 32), this value seems underestimated.

The production model used for all pelagic species taken in purse seine catches suggested initially the size of the MSY at a level of 360 000 tons (for the years 1965-1972 - Newman et al., 1974, quoted after Armstrong et al., 1983). However, after taking into account the poor state of horse mackerel and chub mackerel stocks, the maximum sustainable yield equalled only 325 000 tons (Davies et al., 1981 after Crawford, 1979). Knowing that the mean share of anchovy in purse seine catches equals 80% and relating it to the maximum sustainable yield, we obtain: in the first case (MSY = 360 000 tons) 288 000 tons, in the second (MSY = 325 000 tons) 260 000 tons of anchovy.

The size of the maximum sustainable yield of anchovy at a level of 260-290 tons seems to be a realistic value when compared with the mean actual catch in the past decade, which equalled 298 000 tons. The catch at this level did not, apparently, have a negative influence on the stock.

The estimate based on the analysis of the total catch and effort in the purse seine fishery is not well founded for each component species of this catch, because the changes in the proportion of these stocks and the fluctuation in the recruitment of each of them are too large.

More cautious estimates of the equilibrium yield of Cape anchovy have recently been made by experts of the Republic of South Africa. Taking into account great changeability of environmental conditions and the probability factor, they suggest that the maximum sustainable yield equals approximately 200 000 tons (Payne, 1984).

At present current biomass estimates are made from acoustic surveys and the catch quota is adjusted accordingly. For 1984 a global pelagic quota of 332 560 tons has been set, excluding 28 000 tons of pilchard (no quota was set on other species). Also new split-season policy (see para. 2.11.2) as well as closed areas to purse seiners (False Bay and Walker Bay) have been introduced (South African Fishing Industry, 1985; Botha, 1985, pers.comm.).

A comparison of the situation of the Namibian stock, which is currently depleted with the good condition of South African stock, points out the necessity of considering a different exploitation pattern for each of these stocks as the reason for this state of things, besides natural causes. The age structure of the catches of the Namibian stock compared with the structure for the South African stock reveals that in the former the share of fish age 0 is larger, of fish age 1-3 is smaller, and age group 4 does not occur at all. This is no doubt a result of the use of smaller meshed seines in the north (11 mm), while in the south 12.7 mm meshes are in use.

As is the case with pilchard, the reason for the steady decline of the biomass and recruitment of the Namibian anchovy stock could have been the permanent and excessive catch of age 0 recruits which thus could not reach the age of reproduction, and not overfishing of the adult stock.

2.13 Round herring (Etrumeus teres = micropus)

It is an interesting species as its taste resembles that of the North Atlantic herring. It occurs in shallow shelf waters, from central Namibia along the coast of the Republic of South Africa, both on the Atlantic and Indian Ocean side. Its presence has also been observed in the shallow waters off northwestern Madagascar (Morski Instytut Rybacki, 1975).

Round herring is a pelagic shoal-forming fish. Its main concentration areas are located in Division 1.6, where the species spawns and on Agulhas Bank (Fig.28). The spawning period is extended with a peak from August to October, and the eggs are placed over an extensive area to the isobath of 200 m (Davies et al., 1981).

Crawford (1980) gives after Geldenhuys the following biological parameters of the species (for caudal length):

$L_\infty = 26,19$ cm; $K = 0.3334$; $t_o = -0.1664$;
$W_t = 0.0092\, L_c^{3.0381}1$;
$L_t = 1.1966\, L_c + 0.1199$;
natural mortality $M = 0.5-0.8$

As a rule, it is not a target species during fishing. Off the coast of Namibia it was a by-catch in the purse seine fishery and appeared in negligible quantities except in 1982, when 300 tons were landed, and in 1983 (700 tons). In Division 1.6, where it is most heavily exploited, it usually comprises 5-8% of all purse seine catches (15-30 tons) although in 1978 and 1983, it reached a level of almost 70 000 tons (Table 5). Unlike in the case of pilchard, horse mackerel, and chub mackerel, the new mesh size did not have a negative impact on the level of catches, most likely because the distribution of young year classes is different and therefore subjected to lower pressure of the fishery.

In purse seine catches, fish have lengths of 4.5-22.5 cm, with two distinct modal lengths: 7-8 cm and 16-18 cm.

The stock biomass from Division 1.6 obtained from the VPA remained for years at a level of 50 000 - 100 000 tons (Table 33). There is no information on its level in 1981-1983, but it may be expected on the basis of catch in 1983, that it must have exceeded 100 000 tons.

The recruitment underwent fluctuations from 1 500 to 7 000 million. The highest recruitment observed in the past 10 years was 5 260 million and corresponded with the highest catch (in 1978 - Table 33). These figures suggest that the catch that year was based mostly on recruits, which is not a favourable fact.

Although there is no information about the catches of round herring on Agulhas Bank, it is observed that in the area between 21° and 27°E, in the southern winter (March-July), the adult stock may be found there. Sample catches of the USSR and the Polish research vessel "Professor Siedlecki"in May-June 1975 enabled the localization of round herring concentrations and the determination of their nature. They occurred mostly at depths of 50-120 m and were either mixed with chub mackerel and horse mackerel or homogeneous. The stock was of a large density as the c.p.u.e. attained by the research vessel was as high as 5 700 kg per hour fished. The modal lengths of fish (20-23 cm L_t) pointed out the fact that it was an adult part of the stock, and the recovering gonads state indicated that the stock was in its feeding period. The largest fish had a length of 27 cm (Morski Instytut Rybacki, 1975).

Regulatory measures with respect to round herring in Division 1.6 consists only of a constant annual catch quota for the whole purse seine fishery, which also covers the remaining pelagic species. This limit - 380 000 tons per annum - is questioned by the experts of the Republic of South Africa as being too high.

Simulated catch for a 10-year period with a reduced limit of 360 000 tons and under the assumption that recruitment remains at the same level indicates that the sustainable yield of round herring would become stabilized at a level of approximately 20 000 tons (Shelton, 1982). This magnitude, confronted with an historical series of effective catch would seem to protect the stock against overfishing. If exploitation was limited to fish who had reached their first sexual maturity, this figure could probably be higher.

2.14 Chub mackerel (Scomber colias = S. japonicus)

Despite its great commercial importance, chub mackerel is a little known species and its biological parameters have not been fully determined.

In the ICSEAF Area, it occurs in all statistical divisions, including the oceanic subareas 4, 5 and 8, although it is important for the fishery only in the area of activity of the Benguela Current (Divisions 1.3, 1.4, 1.5 and 1.6) and to a lesser extent on Agulhas Bank. In Divisions 1.1 and 1.2 and off the southeastern coast of Africa it is only sporadically found in the catch and its numbers are small.

Chub mackerel is a typical shoal-forming and migratory species. It begins to form shoals at a length of 3 cm although the most compact shoals consist of adult specimens (Collette and Nauen, 1983). The concentrations of adult mackerel move very fast so it is impossible to conduct directed fishery on a given fishing ground for more than 10-14 days; after several days, chub mackerel shoals move in an unknown direction, probably often towards the open sea.

Table 33

Some parameters for round herring stock fished by purse seiners in Division 1.6 (Davies *et al.*, 1981)

Year	Catch % in '000 t	Biomass '000 t	Recruitment $x10^6$
1958	0.8		
1960	0.1		
1962	0.1		
1963	0.2		
1964	2.7	21.5	1 280
1965	8.2	34.5	1 490
1966	15.4	48.4	2 040
1967	32.0	57.7	3 160
1968	30.3	52.1	7 420
1969	23.3	47.2	6 310
1970	23.7	61.8	5 310
1971	21.6	56.6	1 260
1972	20.6	49.6	1 530
1973	28.7	46.1	1 560
1974	1.3	40.1	4 090
1975	23.6	80.1	4 610
1976	11.7	99.9	2 640
1977	35.0	115.0	1 820
1978	67.0	92.1	5 260
1979	21.0	37.4	1 820
1980	14.1	33.3	485
1981	24.3		
1982	31.2		
1983	69.0		

In the area influenced by the Benguela Current and on Agulhas Bank, there is probably one stock. On the basis of length and age composition of catches in each division it is believed that chub mackerel spawn in Division 1.6; specimens of age 0, with a minimum length of 6-7 cm, are found only there, while in the other divisions, only adult specimens have been encountered (ICSEAF Samp.Bull.No.10; ICSEAF, 1983b; ICSEAF, 1984f).

The fact that mackerel from these divisions belong to one stock is also confirmed by the gradual movement of seasonal catch peaks along the coasts of Namibia and the Republic of South Africa (Crawford and de Villiers, 1984).

According to these authors, chub mackerel begins spawning at age 3-4 or even older, during the southern winter and it is then that it becomes available to purse seine fishery. Juveniles in age group 0 inhabits the coastal zone, usually from January to May and is also intensively fished by purse seiners. In the second half of the year young chub mackerel move offshore and return the next year, at more or less the same time (Fig.29). Upon reaching age 3, shoals usually composed of specimens with similar lengths, undertake longer migrations along the shore, changing also the range of their vertical distribution. At that time, they may be taken with trawl, both in the pelagic and near-bottom layer.

A part of the adult stock undertakes with age more and more distant feeding migrations northward. This may be inferred from the changes in the values of modal lengths of fish from trawler catches in subsequent years, and divisions. For example, the year class of 1975 was probably a strong one (according to Crawford and de Villiers, 1984 it was the year class of 1977), which predominated at a modal length of 25 cm in 1977 in Division 2.1, and then at a modal length of 43 cm in 1979 in Division 1.5 in 1980 - in Division 1.4 (length of 53 cm), and in 1981 - in Division 1.3 (length 55 cm). The same year class was also taken in 1982 and 1983 in northern divisions, when the fish reached a length of 60-68 cm (Fig.30).

The chub mackerel growth parameters as given by Baird (Crawford, 1980) are the following:

$$L_{\infty} = 68.01 \text{ cm};\ K = 0.207;\ t_o = -0.9845;\ W_t = 0.0049\ L_c^{3,3112}$$

The above parameters refer to caudal length (L_c). Their transformation to total length (L_t) and fork length (L_f) may be made according to Baird by means of the following formula:

$$L_t = 1.1925\ L_c + 0.8807$$

$$L_f = 1.1065\ L_c + 0.2113$$

Natural mortality is estimated at a level of $M = 0.25$.

2.14.1 Fishery and stock assessment

First catch statistics for chub mackerel come from 1954 for Division 1.6; for the whole ICSEAF Area, by division, from 1971.

The total chub mackerel catch in the ICSEAF Area in the years 1971-1983 was at an average level of 50 000 - 60 000 tons, fluctuating from a high of 200 000 tons in 1978 to a low of 16 000 tons in 1980. The highest catches are recorded in Divisions 1.3, 1.4, and 1.6 (Table 34).

Off the coast of Namibia and on Agulhas Bank, chub mackerel is caught exclusively by bottom and mid-water trawl; in Division 1.6, in the past ten years (1975-1985), both purse seiners and trawlers were used, and before 1975 almost exclusively purse seiners. The trawlers fishing off Namibia belong to countries with a centrally planned economy, the Republic of South Africa, and Spain while the purse seine fishery in Division 1.6 is operated exclusively by the Republic of South Africa (Tables 5 and 35).

Trawl catches made with a mesh size of 60-110 mm are based on the adult stock; in Divisions 1.6-2.1 these mackerel have a length range of 25-60 cm, off the coast of Namibia - they belong to the oldest age groups, corresponding with lengths of 37-65 cm, usually above 50 cm (L_t).

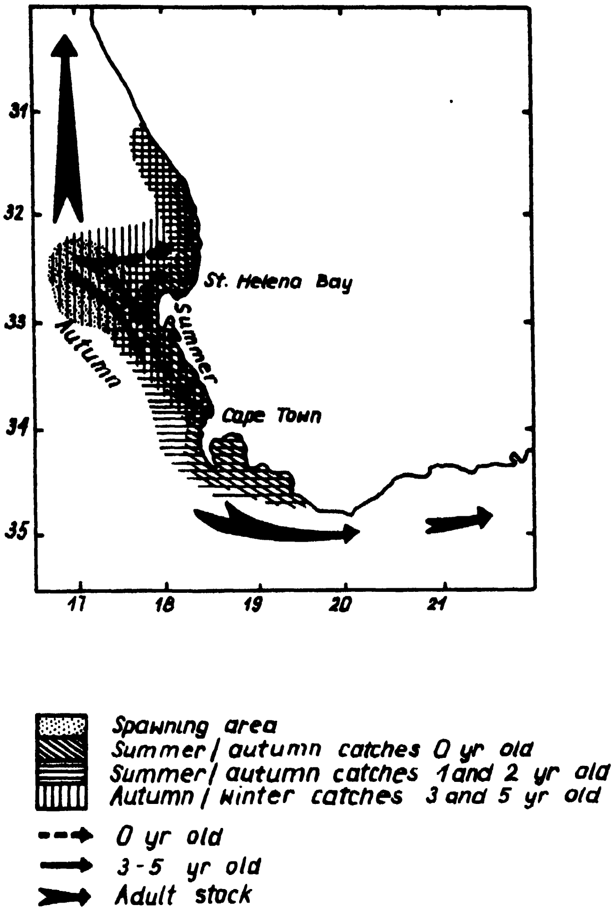
31
32
33
34
35
17
18
19
20
21
St. Helena Bay
Summer
Autumn
Cape Town
Spawning area
Summer / autumn catches 0 yr old
Summer / autumn catches 1 and 2 yr old
Autumn / winter catches 3 and 5 yr old
0 yr old
3-5 yr old
Adult stock

FIG.29 Main spawning area, general directions of the migrations and catch locations for different components of the chub mackerel in Division 1.6 (Davies et al., 1981, modified)

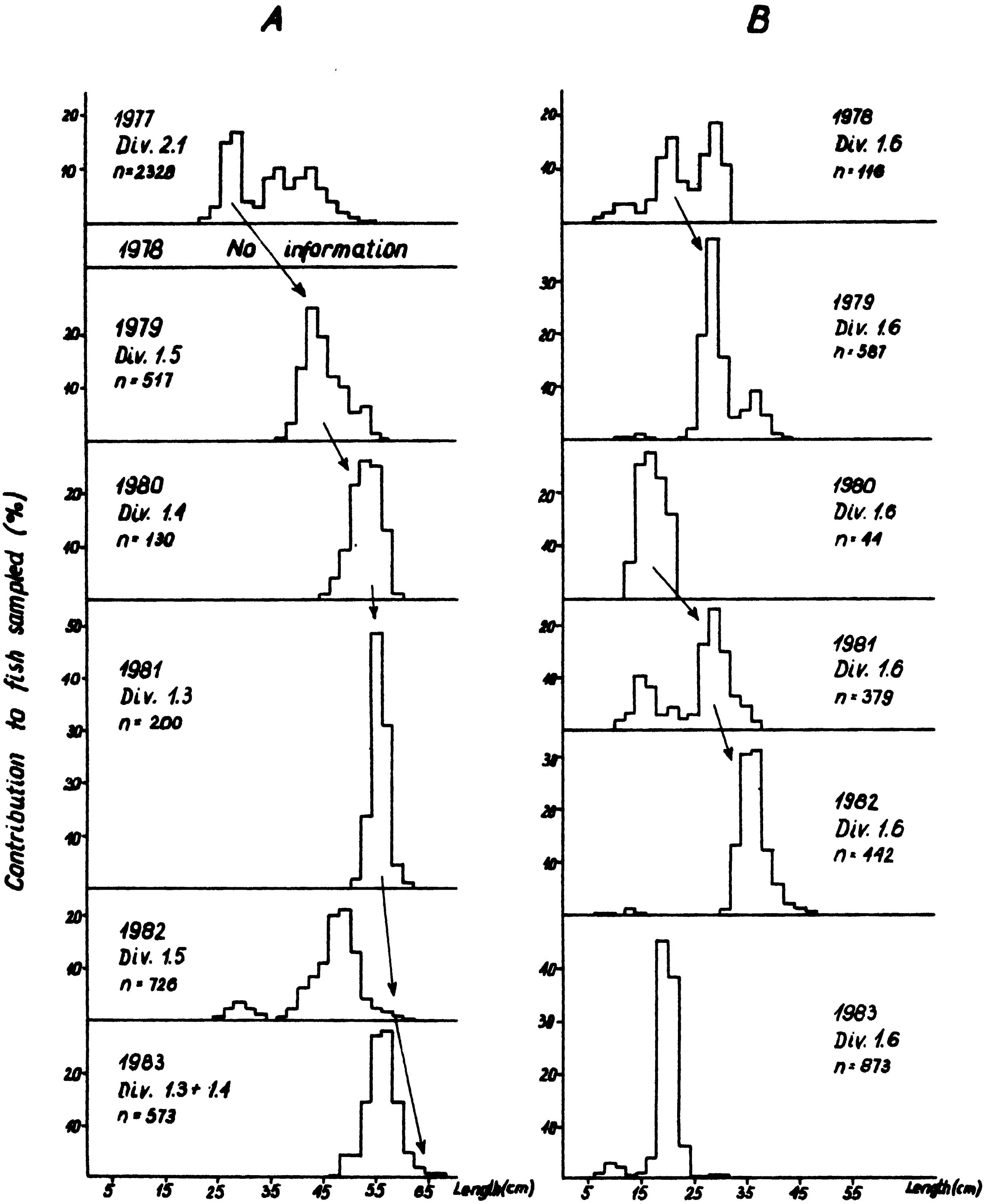

FIG.30 Length distribution of chub mackerel fished by trawlers (A) and purse seiners (B) in the ICSEAF Area, 1977-1983. Pointers indicate probably the same year classes occurring in catch through successive calendar years. Source of basic data: ICSEAF Sampl.Bull.Nos. 6-10; ICSEAF, 1983b; ICSEAF, 1984f

Table 34

Catches of chub mackerel in the ICSEAF Area, 1971-1983

('000 tons)

Year	ICSEAF Divisions:												
	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	4	5	8	NK	Total
1971	0.0	0.0	1.3	0.9	0.2	55.0	0.1	0.0	-	-	0.0	-	57.5
1972	0.0	0.8	2.0	0.9	0.4	56.7	0.0	-	-	-	-	0.0	60.9
1973	-	0.1	0.7	3.8	0.5	59.5	0.1	0.1	-	-	-	0.0	64.8
1974	0.2	0.1	0.3	0.8	0.4	31.3	0.1	-	-	-	-	0.0	33.3
1975	-	0.5	2.4	1.0	0.6	69.9	-	-	-	-	-	0.0	74.4
1976	-	0.6	6.0	33.9	4.5	3.4	0.9	2.3	-	-	-	0.1	51.7
1977	0.0	4.1	64.0	51.3	0.9	29.4	3.8	1.0	-	0.0	0.0	3.3	157.8
1978	0.0	0.0	76.0	121.8	1.0	2.4	0.0	0.2	0.1	-	-	0.0	201.5
1979	0.3	0.0	8.1	13.4	1.1	5.8	4.2	0.5	-	-	-	-	33.5
1980	-	0.0	1.6	2.6	8.0	1.5	2.4	0.0	-	0.0	-	0.0	16.2
1981	0.1	0.1	12.2	35.6	7.2	2.9	2.6	0.2	-	0.0	-	0.4	61.3
1982	0.0	0.2	21.4	12.5	9.8	4.0	3.1	0.1	-	0.0	-	-	51.1
1983	0.0	0.0	21.4	28.6	6.8	5.3	2.6	0.1	-	-	0.0	-	64.5

Source: Crawford and de Villiers, 1984, and ICSEAF, 1984c

Table 35

Catches of chub mackerel in the ICSEAF Area by country, 1971-1983

('000 tons)

Year	Bulgaria	Japan	South Africa	Poland	USSR	Spain	German Democratic Republic	Other	Total
1971	0.4	0.0	54.2	-	2.9	-	-	-	57.5
1972	0.1	0.0	56.7	0.2	2.6	-	-	1.4	60.9
1973	0.0	0.1	58.8	0.3	5.3	-	-	0.2	64.8
1974	0.1	0.1	30.7	0.8	1.6	-	-	0.0	33.3
1975	0.4	0.0	69.3	0.8	3.4	-	-	0.6	74.4
1976	6.2	0.9	0.7	5.8	36.7	0.7	-	0.7	51.7
1977	3.6	0.9	21.3	4.2	125.9	0.2	0.3	1.3	157.8
1978	0.8	0.0	2.4	2.3	194.2	0.5	0.3	0.9	201.5
1979	0.1	0.0	10.8	0.9	15.2	5.1	1.1	0.3	33.5
1980	0.1	0.0	4.2	0.5	2.2	9.0	0.2	0.1	16.2
1981	1.0	0.2	10.9	1.3	38.9	8.9	-	0.2	61.3
1982	0.5	0.1	13.6	2.2	21.2	10.6	2.7	0.1	51.1
1983	1.9	-	13.3	1.7	37.1	7.2	1.1	2.2	64.5

Source: Crawford and de Villiers, 1984 and ICSEAF, 1984c

Purse seine catches of chub mackerel in Division 1.6 remained from 1954 to 1963 at a level of approximately 30 000 tons per annum. As was the case with horse mackerel and pilchard, the introduction of 12.7 mm meshes in purse seiners in 1964 resulted in an initial increase (the maximum catch of 128 000 tons was made in 1967), followed by a systematic decrease in the catch to 200-3000 tons per annum in the early 1980's. This was accompanied by a downward trend of the biomass and recruitment; the age range of chub mackerel caught and predominating groups were limited to groups 0-1 (Table 36).

Thus, a large part of young chub mackerel age 0-1 was eliminated from the stock before they could reach the reproduction age. On the example of 1977, it may be inferred that greater recruitment was accompanied by a proportionally higher degree of its elimination.

At present chub mackerel in Division 1.6 is officially recognized as a non-quota species in the pelagic fishery, with legal minimum size limit of 15 cm (total length) by only when caught by line (South African Fishing Industry, 1985). In practice the purse seine fishery can move to this stock without any restrictions, though according to de Villiers, 1985 (personal communication) juvenile chub mackerel is not a target species and,as other juveniles of commercial species, is protected by a standard South African management policy.

Assuming correctly that there is only one stock of chub mackerel in the ICSEAF Area, which spawns in Division 1.6, any degree of elimination of young fish must have had a negative impact on the size of stocks in the remaining divisions.

The chub mackerel fishery was probably affected by unknown environmental factors. In 1976-1978, the total catch declined in Division 1.6 and increased off the coast of Namibia, suggesting a possible migration of part of the adult mackerel stock (Table 34).

The assessment of the whole stock in the ICSEAF Area is fairly difficult. On the one hand, biomass estimation,based on VPA when age composition is poorly known, would be doubtful; on the other hand, the available fragmentary data on c.p.u.e. are not sufficiently representative to be used as an abundance index.

The existing constant annual catch limit for the coast of Namibia (200 000 tons) determined by ICSEAF each year since 1980, should be treated as a precautionary measure. It is not based on scientific grounds. Objections raised by Crawford and de Villiers (1984) against such recommendation seem to be justified since it is very doubtful that the exploitation maintained at such a high level for years is not connected with a serious risk of overfishing the stock. It would be more correct to recommend, on the one hand, that the catch attained in recent years (65 000 - 70 000 tons in the whole ICSEAF Area) should not be exceeded and, on the other, that young chub mackerel be protected in the spawning areas.

2.15 Snoek (Thyrsites atun)

This is a migratory species, whose biology and spawning areas are not known, and is caught in the deeper water of the shelf and its slope, both in the pelagic and near-bottom layer. It occurs off the coasts of Angola, Namibia, the Republic of South Africa, and Australia (Crawford, 1985).

The migrations of the snoek stock in the ICSEAF Area may be reconstructed on the basis of tagging experiments and seasonal distribution of peak catches in each division.

All specimens tagged near the Walvis Bay and recaptured indicate that the migration is southward along the western coast of Africa. The fishing season lasts from the beginning of the southern spring and in the summer in the northern-most area of activity of the Benguela Current; in autumn, catches increase off the southern coast of Namibia while peak catches in Divisions 1.6 and 2.1 take place in winter (Crawford, 1985). Migration routes are presented in Fig.31.

All fish taken belong to the adult stock, their length ranging from 61 to 122 cm with modal values from 70 to 95 cm, depending on the year (ICSEAF Sampl.Bull.No.10;

Table 36

Some parameters of the chub mackerel stock
in the purse seine fishery in Division 1.6

Year	Catch x10^{3}ton	Biomass x10^{3}ton	Recruitment x10^{6}fish	Age	
				Range	Dominant
1954	4,0	34,7	3,5	0-5	2-3
1955	20,2	48,8	8	1-5	2-3
1956	32,6	45,7	59	0-8	2-3
1957	7,4	37,3	120	3-8	4-5
1958	21,6	55,9	68	0-4	1-2
1959	33,1	66,7	119	0-4	1-2
1960	31,0	69,1	38	0-5	2-3
1961	49,7	70,1	34	0-5	1-2-3
1962	20,4	41,7	59	1-7	2-3
1963	13,2	45,5	252	0-3	0-1-2
1964	50,0	80,2	126	0-3	0-1
1965	41,4	69,0	114	0-7	2-3
1966	53,4	144,0	886	0-6	0-2
1967	128,2	251,0	518	0-5	0-1
1968	91,0	201,0	50	0-8	1-2
1969	91,7	160,0	79	0-8	0-1-2
1970	77,9	108,0	117	0-8	3-4
1971	54,2	89,7	243	0-8	0-1-2
1972	56,7	103,0	119	0-8	1-2
1973	58,8	95,6	57	0-5	1-2
1974	30,7	79,9	250	0-4	0-2
1975	69,3	103,0	23	0-6	1-2
1976	0,5	82,8	7	0-3	0-1
1977	21,3	107,0	30	0-5	0-1-3
1978	2,4	6,3	19	0-3	0-1
1979	2,7	6,7	5	0-4	0-1
1980	0,7	0,3	4	0	0
1981	0,3				
1982	2,7				

Source: Davies _et_ _al._, 1981

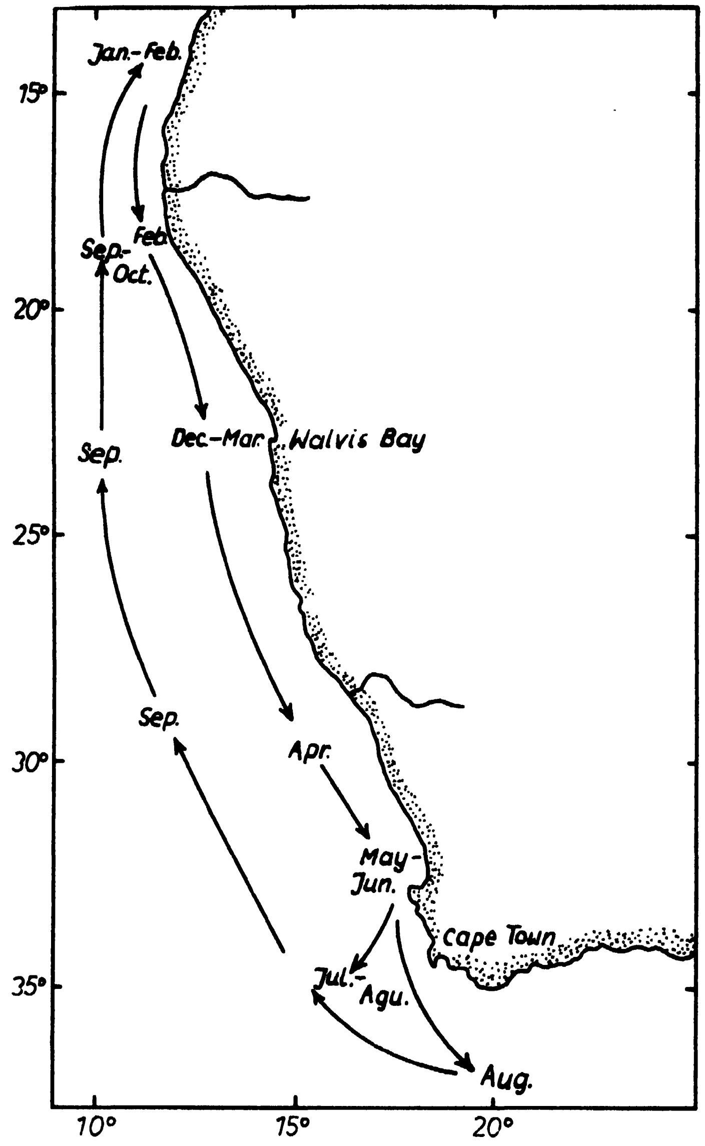

FIG.31 Migrations of snoek, Thyrsites atun around the Namibian coast (after Crawford, 1985)

ICSEAF, 1983b; ICSEAF, 1984f). There is no information on the sites where juveniles below 60 cm in length may be found. This suggests that most likely the species spawns outside the shelf areas of Namibia and the Republic of South Africa, and the migrations observed there are of a feeding character.

From 1972 to 1977, the total catch exhibited an upward trend, from 5 000 to 20 000 tons (Table 37). In 1978, the catch increased four-fold to 82 000 tons as a result of the commencement of fishing operations by the Soviet fleet, using a pelagic trawl. After a period of reduced catches in 1979-1982, the USSR had another record-breaking catch in 1983 (61 000 tons, which constituted 86% of the total catch). The high catches reported by the USSR since 1978 refer to Division 1.3, and - to a lesser extent - 1.4; it may be expected that the catches are made mainly in the frontal zone of the Benguela and Angolan Currents, north and south of the Cunene river. In Divisions 1.1 and 1.2 no country has reported snoek catches.

Before 1978, snoek was taken mainly by the Republic of South Africa in Division 1.6 by longline. When trawl became more and more widely used, especially the pelagic one, the amount of fish taken with its help increased steadily. In 1983, only 6% of the total catch was taken with longlines although the ratio of longline catches to those by trawl in the Republic of South Africa in 1983 was 1 : 1 (Table 38).

Since the age and growth rates are not known, the use of any structural models for stock assessment is presently impossible.

The first attempt to estimate the production capacity of the whole stock was made by Crawford (1985) who had based it on an unconvincing stock abundance index (3-year movable mean from longline catches) and the fishing effort index (total catches divided by longline catches). After this author, the maximum sustainable yield for the whole stock equalled 35 000 tons, which in the light of a series of data on the total catch in the past six years (1978-1983) and the mean for that period equalling 47 000 tons seems to be an underestimated figure.

In order to arrive at more accurate estimates, it would be necessary to improve the system of bio-statistical data, especially those from the Soviet catches, as well as recognize the biology and ecology of the species.

There is also a danger that official statistics may be underestimated for a certain period and by certain countries. For instance, on Polish vessels, snoek caught is not admitted for consumption because of high parasitic infestation of its muscles, and is processed into fish meal. It is thus difficult to estimate its share in the by-catch; it is reported in statistics under "other fishes". Technological improvements in processing might lead to the elimination of parasites and snoek may be considered a target species by some fleets, as was the case with the Soviet fleet.

2.16 Other pelagic fishes

The group of other pelagic fishes includes a number of species of lesser importance for the fishery. Their minor importance may be a result of various factors although some of these species play an important role in the ecosystem of the area.

The total catch of other pelagic fishes in recent years (1978-1983) was 30 000 - 60 000 tons, with a slight downward trend (Table 39). This tendency is not so much a result of a decline in the stocks of these fish but rather of a more accurate reporting of the species composition of catches and the increasing scale of fishery directed at selected species.

2.16.1 Tunas

Tuna fishes included here were not discussed separately in this report because of the specific biology and the fishery itself. The average total catch of tunas is about 10 000 tons; they are mostly caught off the coast of Angola and in Division 1.6, while they are not reported in Divisions 1.4 and 1.5. Thunnus albacares, Thunnus alalunga, and

Table 37

Catches of snoek Thyrsites atun in ICSEAF Area by country, 1972-1983
(ICSEAF Stat.Bull.Nos 2-12 and ICSEAF, 1984c)

(in tons)

Year	Israel	Japan	Poland	Portugal	South Africa	USSR	Other[1/]	Total
1972	-	-	-	-	5 462	-	-	5 462
1973	-	626	-	-	7 935	-	-	8 561
1974	-	312	-	-	9 777	-	-	10 089
1975	-	7	-	-	10 020	-	-	10 027
1976	-	194	-	-	16 273	-	-	16 467
1977	-	22	414	142	18 724	-	182	19 484
1978	-	17	177	4	17 161	64 311	6	81 676
1979	-	-	13	1 222	11 676	18 608	-	31 519
1980	290	2	-	3 642	17 832	34 472	-	56 238
1981	900	-	-	491	9 636	10 062	8	21 097
1982	890	-	11	372	8 980	21 751	2	32 006
1983	96	-	-	789	9 135	60 915	183	71 118

[1/] Cuba, Rep. of Korea, Rumania, Spain

Table 38

Catches of snoek in the Southeast Atlantic in 1983 by country and division
(ICSEAF 1984c)(OTB-bottom trawl. OTM-midwater trawl)

(in tons)

Division	Gear	S.Afr.	USSR	Cuba	Israel	Korea	Portug.	Total
1.3	OTB	41	468	-	-	-	-	509
	OTM	-	48 733	75	-	-	-	48 808
1.4	OTB	-	2 316	-	-	1	-	2 317
	OTM	-	9 398	96	-	-	-	9 494
1.5	OTB	1 564	-	-	96	11	789	2 460
1.6	OTB	1 132	-	-	-	-	-	1 132
	Hook and line	4 522	-	-	-	-	-	4 522
2.1	OTB	1 865	-	-	-	-	-	1 865
	Hook and line	8	-	-	-	-	-	8
2.2	OTB	3	-	-	-	-	-	3
Total	OTB	4 605	2 784	-	96	12	789	8 286
	OTM	-	58 131	171	-	-	-	58 302
	Hook and line	4 530	-	-	-	-	-	4 530
Grand Total		9 135	60 915	171	96	12	789	71 118
%		13	86	0.0	0.0	0.0	1	100

Table 39

Catches of various pelagic fishes in ICSEAF Area, 1978-1985
(ICSEAF Stat.Bull.Nos 8-12 and ICSEAF 1984c)

(in tons)

Species	1978	1979	1980	1981	1982	1983	Main fishing grounds
Pomatomus saltatrix	24	78	-	-	6	363	Angola Coast
Caranx spp.	5 711	4 339	3 462	2 123	1 979	2 214	" "
Lichia spp.	270	1 047	635	842	1 335	852	" "
Seriola spp.	702	508	496	336	62	405	Angola and S.Africa Coast
Other Carangidae	36	18	193	1 362	229	1 945	Angola Coast and SBA 8
Brama spp.	741	4 423	1 097	1 373	1 266	4 529	cosmopolite
Mugilidae	2 227	1 805	2 357	3 802	372	2 333	litoral cosmopolite
Lampanyctodes hectoris	866	9 885	40	10 278	675	1 633	South Africa Coast
Trichiuridae	26 932	15 809	18 337	13 790	12 639	10 810	Angola and S.Africa Coast
Scomberomorous tritor	81	31	92	68	138	138	Angola Coast
Scomberomorous commersoni	-	72	-	-	-	1 085	SBA 8
Tunafishes	9 834	16 125	9 977	12 457	7 110	10 973	Angola and S.Afr. Coast
Other pelagic fish	19 278	4 340	2 316	2 018	1 937	4 131	
Total	66 702	58 480	39 002	48 449	27 748	41 411	

Table 40

Catches of cephalopods in ICSEAF Area, 1978-1983

(in tons)

Species Group	1978	1979	1980	1981	1982	1983	Main fishing grounds	Countries
Sepia spp.	1 316	1 097	99	142	512	348	Angolan Coast	Spain, USSR
Octopus vulgaris	556	119	208	114	74	71	Div. 1.6	Rep. S. Africa
Loliginidae and Ommastrephidae	9 180	10 337	7 016	10 816	9 364	9 489	Namibia and Agulhas Bank	Spain, Japan, Rep. S. Africa
Total	11 052	11 553	7 323	11 072	9 950	9 908		

Source: ICSEAF Stat.Bull.Nos 8-12 and ICSEAF, 1984c

Katsuwonus pelamys are of greater importance, each of them caught in quantities of 2 000 - 2 500 tons per year.

2.16.2 Cutlassfishes

Hairtail, Trachurus lepturus and scabbardfish, Lepidopus caudatus, are of considerable, though secondary, importance in the catches off the coasts of Angola and the Republic of South Africa. Their average annual catch in the period 1979-1983 was about 10 000 - 15 000 tons. The stocks of these fish, especially of Lepidopus caudatus off the western coast of South Africa are not utilized, and the declared catch does not reflect the actual size of the stock. This species is severely infested with parasites, whose cysts live in the muscles of the fish, disqualifying them as food for human consumption. For this reason, as well as because of the small demand on the market, fishing fleets of several countries use hairtails for fish meal, reporting their catches with varying accuracy. It appeared from the observations made in 1972 on the Polish research vessel "Wieczno" that the share of L. caudatus in bottom catches in Divisions 1.3 and 1.4 was less than 1%, in Division 1.6 it equalled 9% (Morski Instytut Rybacki, 1973). In the commercial catches of the Polish fleet in 1977, the share of cutlassfishes was 2% off the coast of Namibia, 8.5% in Division 1.6 and was as high as 30% on the western slopes of Agulhas Bank. That year they constituted 12% of all Polish catches and 1.6% of catches made by all countries in the ICSEAF Area. The determination of the maximum sustainable yield is difficult now, as the access to fishing grounds where it occurs is limited. However, on the basis of the maximum catches of both species in 1977 (44 000 tons), it may be assumed that the MSY for the whole ICSEAF Area is not lower than 40 000 tons.

2.16.3 Carangids

They cover a number of species related to the warmer waters off Angola and Mozambique. In both of these areas, separated by land, there are related species belonging to the genera Caranx, Selar, and Seriola. Although catches of fish from the genus Caranx are reported for the Angolan coast at a level of 5 700 tons in 1978 to 2 000 tons in recent years (1981-1983), their stocks in the Mozambique waters may be considerably higher as their share in sample hauls usually exceeded 10% (Morski Instytut Rybacki, 1975). Of much lesser importance are species connected more with northwestern Africa and whose southern limit of occurrence lies off the coast of Angola. These are Lichia spp., with an annual catch of about 1 000 tons, tasergal, Chloroscombrus, Trachinotus and other littoral species of only local importance. The total catches of these fish in 1978-1983 were at a level of about 5 000 tons.

2.16.4 Brama sp.

This is a cosmopolite species occurring in scattered forms; its reported annual catch equals 1 000 - 4 000 tons, taken usually with mid-water trawls outside the coastal zone. It may be expected that a large part of the fish taken is reported in the statistics of some countries under "various fishes".

2.16.5 Scomberomorus spp.

This occurs in negligible quantities off the coast of Angola (S. tritor) and probably in larger amounts on the Mozambique coast (S. commersoni), where it has usually been a predominant species in sample hauls made with a mid-water trawl (Morski Instytut Rybacki, 1975). The highest catch of the latter species was recorded in 1983 (1 000 tons) which, however, does not reflect the actual size of the stock.

2.16.6 Other species

Special attention should be paid here to numerous species from the group of Myctophidae, pelagic Gobidae and other small-sized fish (below 10 cm in length) forming dense shoals identified as sound scattering layers. The exploitation of their stocks was begun by the Republic of South Africa (Divisions 1.4 and 1.6) when 11 and 12.7 mm mesh purse seines were introduced, although these fish inhabit the whole ICSEAF Area. At first their catches were quite substantial, equalling, for instance, 42 000 tons (mostly *hectoris*) for Division 1.6 in 1973. Between 1978 and 1983, the catches considerably, not exceeding 1 000 tons, with the exception of 1979 and 1981, when 10 000 tons were taken (Newman, 1977). According to expert opinion, the stocks of these fish are large, up to *several hundred thousand tons* (Gulland, 1971). A similar opinion may be arrived at on the basis of the results of the Polish expedition on the research vessel "Professor Siedlecki" (Morski Instytut Rybacki, 1974); the observed sound scattering layers extended over many miles along the coast of the Republic of South Africa and were identified as fish from the group of Myctophidae (mostly *Maurolicus muelleri*). However, the size of these stocks has not been determined.

The resources of small fish identified in the Mozambique waters are equally large (Morski Instytut Rybacki, 1975). They included such shoal-forming fish as *Pellona ditchella*, *Trisocles malabaricus*, *Secutor insidiator*, *Rastrelliger kanagurta*, and others. These stocks are practically unexploited, mostly because of the low c.p.u.e. attained, small size, and great species diversity of catches.

In conclusion, it may be said that the catches of other pelagic fish reported so far at a level of 30 0000 - 60 000 tons do not reflect the resources of these fishes. The probable potential catch of various commercial fishes only is not lower than 60 000 tons.

The potential catch of fish from sound scattering layers is impossible to determine now. However, it is possibly higher than the figure given by Newman (1977) - *100 000 tons*.

2.17 Cephalopods

When compared with other areas, the catches of cephalopods in the ICSEAF Divisions are insignificant. Among the species taken are cuttlefish in Division 1.1, squid, *Todarodes sagittatus angolensis* and *Todaropsis eblanae* off Namibia, *Loligo reynaudi* in Division 1.6 and Subarea 2, and *Octopus vulgaris* in Division 1.6.

The total catch of cephalopods in the period 1978-1983 was 7 000 - 11 000 tons (mean of nearly 10 000 tons), without a visible trend (Table 40). The share of cuttlefish mostly taken off the coast of Angola and octopus off the coast of the Republic of South Africa as by-catch is small and ever decreasing, probably due to the generally less frequent use of the traditional bottom trawl. In 1983, only 350 tons of cuttlefish were taken in Division 1.1 (USSR) and 70 tons of octopus in Division 1.6 (Republic of South Africa). Their stocks are not known, but it may be expected that they are not large enough to support a directed fishery.

Off the coast of Namibia *Todarodes sagittatus* is more important of the two species of squid; its stock is exploited mainly by Spain, as incidental catch in the hake fishery. The length of the mantle of this squid ranges from 21 to 47 cm (mean 30), with season-dependent fluctuations from 24 to 34 cm (Sanchez *et al.*, 1984). The total catch of squid off Namibia in 1983 was 5 500 tons, and the present stock status is believed to be satisfactory (ICSEAF, 1985a).

The stock of *Loligo reynaudi* on Agulhas Bank is at present exclusively exploited by Japan and the Republic of South Africa, with Japan operating two large trawlers (tonnage groups 7 and 8) in a fishery directed at this species. The fishing season lasts from December to March inclusive; in the remaining months, squid occurs as by-catch. The average annual catch in recent years (1981-1983) was 3 500 tons. The data on c.p.u.e. in days and hours fished by Japanese trawlers, tonnage groups 7 and 8, are available only for that period. They are as follows (ICSEAF Stat.Bull.Nos.11-12; ICSEAF, 1984c):

Year	OTB - 7 trawlers		OTB - 8 trawlers	
	t/d	t/h	t/d	t/h
1981	5.8	0.40	7.8	0.54
1982	4.6	0.28	4.8	0.34
1983	5.5	0.35	6.4	0.31

ICSEAF experts believe that the stock status is not satisfactory, although there is no series of data long enough to confirm this opinion (ICSEAF, 1985a).

Squid is a promising object of fishery in the future and its present catch at a level of 10 000 tons does not reflect the size of their resources and potential catch is estimated roughly at a level of several hundred tons (Gulland, 1971). The attempts hitherto undertaken to develop the squid fishery encountered difficulties caused partly by insufficient information on the biology and distribution of several oceanic species of squid inhabiting the ICSEAF Area (Roper et al., 1984). Besides, the usually small dimensions of some oceanic squid species and the undeveloped fishing and processing techniques slow down the progress in this fishery.

2.18 Other molluscs

Three groups of mollusc species are of importance to the coastal fishery of the Republic of South Africa: snail of the species Haliotis midae in Division 1.6, wild and cultivated oysters in Subarea 2, and other clams in Division 1.6.

The total catch of these molluscs is presented in Table 41, together with fishing effort statistics for H. midae.

Haliotis midae (abalone) is of great importance in the fisheries industry of the Republic of South Africa and is high-priced on the market, in spite of relatively low catches. It is caught in the coastal zone, down to a depth of 25 m, by licensed divers. This snail is characterized by a very slow growth rate; that is why, after over-fishing and introduction of regulatory measures, the recovery of the stock took so long. Its catches have been limited for the past few years; besides, a minimum shell width of 11.4 cm - as 50% of the maximum width - has been introduced (Newman, 1977). These regulatory measures undertaken by the Republic of South Africa have resulted in a stabilized catch and c.p.u.e. between 1977 and 1983, equalling, respectively 700 tons/year and 100 kg/h of diving.

The remaining molluscs are of lesser importance although their cultivation on the southern coast of the Republic of South Africa is increasing. The total catch of Bivalvia is recently at a level of 350 - 450 tons.

Some clams (white mussels) are being periodically destroyed by a poisonous dinoflagellate, Convaulax catanella, appearing in great numbers in some years, and provoking "red tides". Widespread poisoning took place in 1966 and 1980; dying white mussels were found on the beach in great quantities. As a result of this poisoning, the catches of these clams dropped considerably in the following years (Sea Fisheries Institute, 1982).

2.19 Crustaceans

The stocks of crustaceans include various species of prawn and shrimp, mainly off the coast of Angola and Mozambique, rock lobster taken in southern ICSEAF Divisions (1.5, 1.6, Agulhas Bank) as well as around the islands in the Southeast Atlantic, and crabs.

2.19.1 Shrimp

Within the ICSEAF Area there are two main areas rich in shrimp: the coast of northern and central Angola and Mozambique waters.

2.19.1.1 Divisions 1.1 and 1.2

In Angola, the major species out of several shrimps is Parapenaeus longirostris with a mean length of 5.8-10.5 cm. It occurs at a depth range of 150-300 m. The stock biomass estimate made for the whole Angolan coast during the expedition of the "Isla de la Juventud" in 1976/1977 was almost 10 000 tons, including 6 800 tons between Luanda and Cabinda (FAO/PNUD, 1977).

Table 41

Catch of mollusca in the ICSEAF Area in 1977-1983, and c.p.u.e. statistics for abalone fishery

Year	Abalone Division 1.6			Oysters SBA 2 in tons	Mussels Div. 1.6 in tons
	Catch in tons	Effort in hour of diving 1/	c.p.u.e. kg/hour of diving		
1977	736	7 406	99,4	49	6
1978	799	8 170	97,8	203	-
1979	735	7 808	94,1	275	11
1980	739	7 678	96,2	331	13
1981	733	7 318	100,2	455	17
1982	727	7 737	94,0	87	14
1983	660	6 592	100,1	349	12

Source: Annual report 1982, ICSEAF Stat.Bull.Nos 7-12 and ICSEAF, 1984c

1/ Approximated, using 3,27 coefficient for converting days of diving into hours of diving (based on relation: days to hours in 1980).

Table 42

Catches of crustaceans in the ICSEAF Area, 1972-1983
(ICSEAF Stat.Bull.Nos 2-12 and ICSEAF, 1984c)

(in tons)

Year	Shrimps and prawns			Rock lobster					Crabs	Other crusta-ceans	Total crusta-ceans
	Div. 1.1+1.2	SBA 8 3/	Other Divi-sions	Jasus lalandi		Palinurus gilchristi	J.tristani 4/	Other species and Divisions			
				Div.1.5	Div.1.6	Div.2.1+2.2	SBA 4				
1972	8 122 2/	7 120	1 224	2 396	5 761		(816)	126	2	408	25 159
1973	8 866	8 977	-	3 179	4 835		(812)	170	8	996	27 031
1974	9 124	7 105	258	3 193	5 851	(800) 4/	(660)	1 185	84	1 749	28 549
1975	11 420	4 015	299	1 697	6 091	(1 946) 4/	(746)	1 070	182	111	24 885
1976	10 002	5 629	2	1 400	4 796	970		61	418	329	23 607
1977	1 787	5 676	235	1 796	5 318	554		-	357	922	16 645
1978	1 216	894	379	1 297	5 903	1 494		71	1 637	253	13 144
1979	217	1 027	244	1 504	5 275	915		291	1 572	98	11 143
1980	-	1 508	-	1 249	5 243	193		442	689	456	9 780
1981	-	524	-	1 394	3 958	340		1 573 1/	2	91	7 882
1982	-	561	-	1 359	3 702	372		29	5	71	6 099
1983	-	1 279	-	1 641	3 085	797		177	302	65	7 346

1/ Including J. Lalandi in Subarea 1.0;

2/ after Campos Rosado, 1974;

3/ since 1975 Mozambique catches not included;

4/ after Newman, 1977, not included to total catch.

The remaining species of shrimp are of lesser importance, either because their populations are not so abundant, or they are too small, even though their total biomass is much greater than that of P. longirostris. These are the following: Aristeus varidens Plesiopenaeus edwardsianus, Penaeus notialis, and Solenocera membranaceum. There are also other species, which do not occur in commercial concentrations; together with the species Syciona, they occur at a depth range of 150-500 m. Between Benguela and Luanda small shrimp may constitute 93% and between Luanda and Cabinda 98% of the catch directed at shrimps. The biomass of shrimp for the whole area between Benguela and Cabinda was estimated at a level of 32 800 tons, including 24 000 tons in the Luanda-Cabinda area (FAO/PNUD, 1977).

The shrimp fishery off the coast of Angola passed through bad and good periods. It began to develop in 1967 with the help of the Spanish fleet. Catches of shrimp, mostly P. longirostris, P. edwardsianus and A. varidens, increased systematically from 1 200 tons in 1967 to 8 100 tons in 1972 (Campos Rosado, 1974), and 11 400 tons in 1975 (Table 42). According to Campos Rosado quoted above, the increase in fishing effort (number of landings) in 1967-1972 was accompanied by the proportionally higher catch, with no visible downward trend in catch per unit of effort. This would suggest that the maximum level of exploitation had not been reached yet.

The Spanish fleet ceased to exploit the stock in 1977 and was replaced by the Cuban fleet, which continued to fish until 1979. The catch during that period dropped to 1 800 tons in 1977 and 200 tons in 1979. Cuban trawlers from a group of 50-150 GRT in 1977 and 1978 had a c.p.u.e. of 250 and 590 kg per day fished respectively, while Spanish trawlers of 250-500 GRT had in 1978 a c.p.u.e. of 1 200 kg per day fished (ICSEAF Stat. Bull.Nos.7 and 8).

According to official statistics, the shrimp stock off the coast of Angola has not been exploited since 1980. Although Angola continues to report (until 1983) the catch of crustaceans, it is not known which groups of organisms are included under that name, and the size of the reported catch (50-100 tons) cannot have any impact on the state of the stocks.

Assuming that Angola in fact does not exploit the stock of shrimp, and statistics presented by ICSEAF for other countries are correct, it may be said that the multi-species stock of Angolan shrimps is not utilized. On the basis of the data of Campos Rosado (1974) and the size of the catch prior to 1975, it may be assumed that the potential catch is not smaller than 8 000 tons and, possibly, may range from 8 000 - 11 000 tons depending on the degree of utilization of small-sized shrimp.

2.19.1.2 Coast of Mozambique (Subarea 8)

The main fishing grounds of shrimp are located in three sectors: (i) between Antonio Enes and the Zambezi river delta; (ii) on Sofala Bank, south of Beira; (iii) in the Maputo Bay.

The first ground is of the greatest importance; it is inhabited by Hymenopenaeus spp. (= Haliporoides spp.), Penaeus spp., and, in the by-catch, Nephrops andamanicus (king prawn). The ground in Maputo Bay has lesser importance; the shrimp found there belongs to the genus Penaeus (P. indicus, P. semisculatus, P. japonicus), and the species monoceros. The fishing ground on Sofala Bank is least known as far as its are concerned, although its species composition is similar to that found in Maputo Bay.

The multi-species stock of shrimp off the Mozambique coast has been intensively exploited, according to the available catch statistics, since 1969, when the Spanish fleet appeared in the area. In 1978, the Spanish fleet left the area and was replaced by the fleet of the German Democratic Republic, which continues fishing there today, and the fleet of the Republic of South Africa, operating there from 1978 to 1980 only.

Catch statistics are very unreliable and differ considerably depending on the source (Newman, 1977; Freitas and Araujo, 1974; ICSEAF Stat.Bulls.). Besides, since 1974, the catches made by Mozambique have not been included in the ICSEAF statistics. The most representative data refer to 1972 and 1973, when the total catch was 7 100 and 9 000 tons, respectively (ICSEAF Stat.Bull.Nos.2 and 3).

The information on fishing effort and c.p.u.e. come from the first and last years of exploitation. It appears from the data from Maputo Bay fishing ground (Table 43) that in the years 1965-1973, the stock was not fully exploited, and small, 12 m long trawlers attained low c.p.u.e.'s.

The situation on the Antonio Enes-Zambezi delta fishing grounds was different - the stock was heavily exploited in 1968-1977, as may be seen from the size of the catch and the downward trend of the c.p.u.e. from 513 kg/day in 1971 to 320 kg/day in 1973.

Information on the c.p.u.e.'s attained in recent years (1981-1983) come from the operations of the fleet of the German Democratic Republic,, consisting of OTB-6 and OTB-7 trawlers; it suggests that the stocks inhabiting the coast of Mozambique are in good condition. This fleet attained the following results:

Year	Catch (tons)	Effort days fished	c.p.u.e. kg/d
1981	524	965	543
1982	561	905	620
1983	638	850	751

The absence of information on catch results of the Mozambique fleet makes it impossible to determine the present state of the stocks. From the data of Freitas and Arauja (1974), taking into consideration the unknown fishing grounds on Sofala Bank, it appears that the potential catch should not be smaller than about 12 000 tons.

2.19.2 Rock lobsters

There are three main species of rock lobster in the ICSEAF Area: Jasus lalandi caught in Divisions 1.5 and 1.6; Jasus tristani caught round the islands situated in Subarea 4 on the South Atlantic Ridge - Tristan de Cunha, Inaccessible, Gough, Nightingale, and on Mont Vema; Palinurus gilchristi inhabiting Agulhas Bank (Divisions 2.1 and 2.2) and in smaller quantities - the coast of Natal (Subarea 8).

The catches of J. lalandi and P. gilchristi in the past conducted by various countries (Australia and Japan, among others) are now made exclusively by the Republic of South Africa.

The stock of J. tristani inhabiting the exclusive and territorial waters round the British-dependent territories were exploited in the past both by the local fishery and the vessels of the Republic of South Africa. Since 1975, no country has reported catches in this area. The catches in the preceding years (1955-1975) fluctuated between 600 and 1 000 tons, and the annual catch limit determined by the South Atlantic Islands Development Corporation at 900 tons seems to correspond with the production capacity of the stock (Newman, 1977). Since 1976, there has not been any information about the size of the catch of J. tristani and its stock situation.

Detailed information on the biology and fisheries of the remaining two species are given by Newman (1977). The information presented in this section supplements Newman's report and is based on the data supplied by the Republic of South Africa to the ICSEAF Secretariat in recent years (ICSEAF Stat.Bull.Nos.2-12; ICSEAF, 1984c).

The total rock lobster catch of the Republic of South Africa in 1972-1983 exhibits a downward trend (Table 42). This is especially true about Divisions 1.5 and 1.6 (J. lalandi) which are of considerable importance to the fishery. The highest catches for both divisions were 20 000 tons in 1952-1953; in the 1960's they dropped to 15 000 tons,

Table 43

Effort and c.p.u.e. statistics for prawn and shrimp fished by Spain and Portugal in Subarea 8. Effort expressed in Portuguese vessels unit (Freitas and Araujo, 1974)

Year	Lourenco Marques Bay			Antonio Enes - Zambezi Delta		
	Catch (t)	Effort boat days	C.p.u.e. (kg/d)	Catch (t)	Effort boat days	C.p.u.e. (kg/d)
1965	4	120	56			
1966	60	722	83			
1967	43	740	59			
1968	138	3 652	38	41	95	430
1969	189	5 617	34	2 491	5 876	424
1970	165	8 167	20	2 066	4 883	423
1971	746	7 683	97	3 796	7 400	513
1972	779	6 399	122	4 998	13 222	378
1973	587	5 205	113	8 338	26 057	320

Table 44

Abundance indices for rock lobster in Divisions 1.5, 1.6 and Subarea 2

Year	*J. lalandi* (kg/hoop net day)		*P. gilchristi* (kg/trap day)
	Div. 1.5	Div. 1.6	SBA 2
1968		6.4	
1969		6.0	
1970		8.0	
1971	11.9	8.8	
1972	24.0	9.2	
1973	27.8	8.7	
1974	17.7	17.0	6.6
1975	13.3	10.4	2.7
1980	7.2		0.2
1981	7.4	2.5	0.3
1982	10.1	3.4	(0.2)1/
1983	13.2	4.3	0.4

Source: 1968-75 Newman, 1977;
1980-83 ICSEAF Stat.Bull.Nos 10-12, and ICSEAF, 1984c.

1/ kg/traps hauled

and in the 1970's to 8 000 tons; in recent years (1981-1983), they were only at a level of 5 000 tons (Newman, 1977; ICSEAF Stat.Bull. Nos.2-12; ICSEAF, 1984c).

The catches in other divisions, especially on Agulhas Bank and off the coast of Natal (Subareas 2 and 8), referring to P. gilchristi, are much smaller, fluctuating between 190 and 1 500 tons. These fluctuations are most likely caused by the poor knowledge of the biology and spatial - temporal distribution of the species, and not by the actual fluctuation in the stock abundance, as the rock lobster fishery in that area began to develop as late as 1975.

Stock abundance indices presented in Table 44 suggest that although the stock of J. lalandi in Division 1.5 exhibited in 1981-1983 a distinct upward tendency, the recovery of the stock of this species in Division 1.6 is much slower. On the other hand, a series of data on c.p.u.e. for P. gilchristi expressed in kg per trap day does not exhibit any substantial changes in the period 1980-1983.

The potential catches for rock lobster suggested by Newman (1977) is 2 000 - 8 000 tons for Division 1.5 and slightly over 10 000 tons for Division 1.6. Assuming, until further information is available, that the potential catch in Subarea 2 does not exceed 1 000 tons, the total maximum potential catch of rock lobster in the ICSEAF Area may approximately equal not more than 15 000 tons.

Strict regulatory measures introduced by the Republic of South Africa (catch and fishing effort limits, fishing seasons, and minimum size of rock lobster) are bringing positive results (increase of c.p.u.e.'s) although the stock is still far from the condition it had in 1950-1965.

2.19.3 Crabs

The species fished is primarily Geryon spp., mostly off the coast of Namibia and the Republic of South Africa, both on the Atlantic and Indian Ocean side, although the area inhabited by the species is much wider, covering also the coast of Angola.

The catch of this species is reported by the Republic of South Africa and, from time to time, by Spain and Portugal. The total catch in the period 1973-1983 fluctuated from 2 to 1 600 tons, with the best results attained in 1978-1980 (Table 42).

It is expected that Geryon is a potentially promising species but there are no data on its biology and stock size.

2.20 Brown and red seaweeds

The main commercially exploited species include the following seaweeds: Laminaria pallida, Laminaria schinzii, and Ecklonia maxima. They are to be found along the western and southwestern coast of the Republic of South Africa, including Cape Agulhas along the coastline of about 1 200 km (Sea Fisheries Institute, 1982).

The total harvest of these seaweeds undergoes substantial fluctuations. In 1972-1974, it equalled 4 500 - 6 000 tons, while in 1975-1977 it increased tenfold to over 50 000 tons, and then dropped to 11 000 tons in 1980. For the years 1981-1983, the Republic of South Africa did not report seaweed harvest (Table 45).

It was discovered that the biomass of Ecklonia renews itself after four years if plants longer than 250 mm were harvested. The intensive exploitation of its stocks in 1975-1977 provoked a discussion among the South African ecologists on its influence on the ecosystem, especially the stocks of clams and rock lobsters (Newman, 1977; Sea Fisheries Institute, 1982).

The investigations and experiments currently conducted are not only aimed at the determination of the actual influence of its exploitation on the environment, but also at the working out of a pattern of management of these "underwater meadows". It is proposed, among others, to restrict exploitation to Ecklonia only, in narrow 10 m belts with with 30 m intervals of unexploited terrain in between, in four-year cycles, with the allowable size and best time of harvesting taken into account (Sea Fisheries Institute, 1982).

Table 45

Seaweed harvests from South African Coast

(in '000 tons)

Year	Brown seaweeds	Red seaweeds	Total seaweeds
1972	3,2	1,2	4,4
1973	4,8	1,1	5,9
1974	4,5	0,2	4,7
1975	45,5	0,2	45,7
1976	43,0	0,2	43,2
1977	54,4	0,1	54,5
1978	25,7	0,2	25,9
1979	13,8	0,6	14,4
1980	10,6	0,7	11,3
1981	-	-	-
1982	-	-	-
1983	-	-	-

Source: ICSEAF Stat.Bull.Nos 2-10

Table 46

Total catch in relation to the 200 m and 1 000 m shelf contour in the ICSEAF Area

ICSEAF Divisions and Subareas	Mean catch ' 000 t		Catch in kg/ha			
			200 m shelf		1 000 m shelf	
	1972-1975	1981-1983	1972-1975	1981-1983	1972-1975	1981-1983
1.1	32	109	14	49	8	28
1.2	111	150	91	123	51	69
1.3	448	830	230	426	118	219
1.4	990	469	220	104	120	57
1.5	250	160	43	28	24	15
1.6	610	483	108	86	45	35
Subarea 1	2 640	2 210	124	103	62	52
Subarea 2	120	95	11	8	8	7
Subarea 8	12	3	2	0.4	0.7	0.2

The general biomass of the three species mentioned above is estimated at a level of about 2 million tons.

3. SUMMARY AND CONCLUSIONS

3.1 Trends in catches and their species composition viewed against general distribution of resources

Generally speaking, a decline in catches of both demersal and pelagic fishes is observed in the whole ICSEAF Area; their present level of 2.3 million tons is smaller than the maximum level attained in 1968 (3.2 million tons including 1.5 million tons of pilchard (by 1 million tons)).

The downward trend in catches of demersal fishes was caused by a steady decrease in hake catches, from 848 000 tons in 1971-1975 to 427 000 tons in 1981-1983 (a 50% drop). This tendency should be arrested in 1984-1986 as new strong year classes are expected to enter the exploited stock.

The stocks of pelagic fish underwent drastic changes in the past 20 years. This refers especially to pilchard, whose mean catch off the Namibian coast only dropped from 960 000 tons in 1965-1970 to as little as 50 000 tons in 1981-1983, and horse mackerel, whose catch increased in the same period and area from 68 000 to 619 000 tons.

The proportions of the decline in pilchard stocks and the increase in horse mackerel stocks seem to balance each other as far as the use of their food is concerned if we take into account that the food of horse mackerel (zooplankton) comes from a slightly higher trophic level than the food of pilchard (phyto- and zooplankton).

The share of the remaining pelagic species in the total catch did not change much, if we disregard natural fluctuations, typical for some populations of unstable stocks (sardinella, round herring, anchovy) or caused by economic and political factors (the independence of Angola, the introduction of 200-mile exclusive economic zones).

Still, certain symptoms of changes which may take place both under the influence of human activities and environmental conditions become visible. Besides positive ones like the increased recruitment of hake and the recruitment of horse mackerel remaining at a relatively high level, the negative effects caused by the impact of the inflow of warm waters in the Walvis Bay area should be noted. These include the decreased production of eggs by pilchard, a much younger stock of horse mackerel threatening the break-up of the inter-population equilibrium. The negative impact of human activity consists in the mass capture of juveniles of major species for the whole fishery of the Convention Area.

Judging by the size of total catch and catch per hectare of shelf, the highest biological production of the higher trophic level concerning fish took place in Divisions 1.3 and 1.4 (Table 46). This was probably a result of accumulated effects of upwelling in southern divisions.

In recent years (1981-1983), the highest total catch (830 000 tons) and the highest catch per hectare of shelf (426 kg) was recorded in Division 1.3 within the 200 m isobath, where the catch/ha has usually been smaller by 50% (about 230 kg in 1972-75). Similar, though slightly smaller, values were observed earlier in Division 1.4. The size of catch per hectare in the remaining divisions was 3 to 15 times smaller in the areas south and north of Divisions 1.3 and 1.4. In Subarea 8, it was as low as 0.2-2 kg/ha, which indicates that the resources there are small and the fishery on the Mozambique coast undeveloped.

Off the Angolan coast (Divisions 1.1 and 1.2), the catch per 1 ha in 1981-1983 was three times greater than in 1972-1975 (49 kg compared with 14 kg), which may be explained rather by the increased fishing effort of the Soviet fleet than by an increase in stocks. A downward tendency may be observed off the coast of the Republic of South Africa (Divisions 1.5, 1.6, 2.1, 2.2), where the catch per 1 ha decreased by 20% in the same period. Several factors had influenced this - overfishing of several fish stocks in the 1970's, the implementation of catch limits by the fisheries authorities, and a serious decreasing of the fishing effort by the non-coastal fleet.

3.2 Balance of stock utilization and perspectives for the development of the fishery

The general balance of stock utilization in the ICSEAF Area is presented in Table 47; it indicates that the perspectives for the development of the fishery are limited. The present total catch (about 2 300 000 tons) is at exactly the same level which results for the present years from the calculations of safe potential catch ($F_{0.1}$, $f_{0.1}$) and is at least lower by 1 million tons than the maximum sustainable yield (3.3-3.6 million tons). It seems unrealistic to believe that the total catch at the level of MSY may be attained and maintained; it is even inadvisable since the recommended strategy is based on the notion of optimum sustainable yield (OSY). It is, however, possible to come close to a level of 3 million tons, which would depend on favourable environmental conditions and rational management.

As far as catches of demersal species are concerned, where hake is the dominant species, an increase of its catch from the present level of 400 000 - 500 000 tons to the theoretically possible figure of 700 000 - 800 000 tons depends not only on high recruitment, observed at present, but also on allowing for an increase of the stock biomass, which is not so certain in the light of information recently available on the stock.

The perspectives for increased catches are much wider with respect to pelagic species, although even here the increase by 1 million tons from the present safe level of 1 500 000 - 1 600 000 tons to a maximum level of 2 400 000 - 2 500 000 tons could take place under very special circumstances. It should be noted that a rapid development of the population of one species (e.g., horse mackerel) is accompanied by a decline in the development of another (e.g., pilchard) and vice versa. This fact was first pointed out by Kolarov and Prodanov (1985); it is also confirmed by the data in Table 47. The occurrence at one time and in one area of a violent demographic high (termed "eruption" by Garcia, 1984) in both of these populations is rather doubtful. The sum of MSY's given in Table 47 should be therefore reduced accordingly (by about 300 000 - 500 000 tons).

Although any opinion concerning the possibility of maintaining the abundance of a given unstable population at a high, constant, and sustainable level has been sharply and correctly criticized (Garcia, 1984), it should be noted that such equilibrium must exist if we look at the whole ecosystem. A population of fish which disappears may be replaced by a population of another species (edible or not). The difficult problem thus consists of the working out of such fishery regulatory measures which would ensure the conservation of the most sought after species.

Under the current conditions, with respect to the pelagic fish in the Benguela Current, only the anchovy population is being protected in order to try to keep it at a safe level. The regulatory measures in practice (minimum mesh size of 11 mm in the purse seine fishery off Namibia, and 12.7 mm of the South African coast) do not allow for or seriously restrict the possible process of eruption of such major species as pilchard, chub mackerel, and - recently - horse mackerel.

In the light of the above remarks, the attainment of the theoretically possible total equilibrium yield of 3 million tons, including about 0.9 million tons of demersal fishes and about 2.1 million tons of pelagic fishes on the basis of hitherto exploited stocks would be difficult and require changes in the strategy of the whole fishery.

It is no doubt possible to begin the exploitation of small-sized species from sound scattering layers and underexploited areas (the Mozambique coast) but these fish are of no direct use for human consumption, and fishing techniques and processing technology are still not developed to a sufficient degree.

The insufficient development in fishing gear and techniques gives no hope for the future exploitation of fishing grounds with difficult access, both on the shelf and its slopes (canyons, tectonic elevations, rocks) and in any case the stocks of these fish are fairly limited.

Table 47

Summary of exploitation and the present state of stocks in the ICSEAF Area

Species	ICSEAF Division	Mean catches ('000 t)				Maximum sustainable yield ('000 t)	Present safe catch ('000 t)	State of stock in 1983	Remarks and assessment method
		1965-1970	1971-1975	1976-1980	1981-1983				
Hake	1.1 + 1.2	-	4	10	2	10 - 20	ca 10	Unknown	Catch statistics
	1.3 + 1.4	268	395	242	172	306 - 350	266	Heavily exploited; increase in recruitment and biomass.	Dynamic production models
	1.5	183	222	138	124	178 - 210	163	Same as in Div. 1.3 + 1.4	Same as in Div. 1.3 + 1.4
	1.6	171	163	107	87	150 - 165	82	Heavily exploited	General production model
	2.1 + 2.2	30	68	49	42	56 - 70	44	Heavily exploited; no recruits	Same as in Div. 1.6
	Total	652	848	546	427	710 - 805	565		
Kingklip	SBA 1 + 2	4	16	12	9	7 - 33(?)	Undetermined	Probable overfishing	Cohort analysis, not too reliable
Dentex	1.1 - 1.4	37	14	26	11	22(?)	18(?)	Probable overfishing	Cohort analysis, not too reliable
Panga	SBA 2	6	7	3	2	7	6(?)	Underexploited	General production model and "standing stock"
Sole	SBA 1	1	1	1	3	2	Undeter-	Unknown	Catch statistics

Better perspectives are connected with the utilization of squid, especially their oceanic form since stocks of the shelf species are believed to be not substantial (annual catch of about 10 000 tons). However, the exploitation of the stocks of oceanic squid involves considerable costs of scientific investigation and exploration.

In the light of the available catch statistics, the stocks of shrimp and prawn are not fully utilized. The same seems to be true for the crab Geryon. However, access to the stocks of these crustaceans, especially off the Angolan coast, is not easy for non-coastal states, and the local fishery is too ill-equipped for the full exploitation of these stocks.

3.3 Fishery regulatory measures

It is believed that the number of fishing regulations and restrictions in the ICSEAF Area are sufficient for rational stock management if properly implemented and enforced, at least as far as international fishing grounds (outside the 13.5 mile belt of the coastal waters of Namibia) are concerned.

With respect to hake caught mainly on international fishing grounds, these measures did not produce all the expected beneficial effects, probably because of the non-fulfilment of the basic assumptions of the production model and the quota policy. Measures would possibly have been improved by the adjustment of the minimum mesh and the topside chafers, after their selectivity had been more precisely determined. In addition, the Commissioners have in the past had a tendency to over-shoot the quota (Table 15).

As regards the remaining demersal species, usually constituting a small by-catch in the hake fishery, it seems justified to share the opinion of the ICSEAF Stock Assessment Committee (ICSEAF, 1985a) that it is difficult to adjust the possibly necessary regulations for secondary species (e.g., kingklip) to the regulations existing in the hake fishery, which is a decidedly dominant species of primary importance.

The fishery regulatory measures determined by ICSEAF for international fishing grounds are implemented by the member countries and enforced by an international control system as far as mesh size, closed areas, etc., are concerned. However, there is at present no effective control on the quota system. The activities of the fleets of all countries are monitored by special services according to a pre-determined schedule (ICSEAF, 1984d). Any infringements are reviewed at the session of the Standing Committee on International Control, which is also informed about the penalties imposed by the authorities of a given member state on those guilty of infringement. It is worth emphasizing here the considerable role played by South Africa in implementation, monitoring and enforcement.

There are important controversies surrounding regulatory measures with respect to the pelagic fishery, especially regarding horse mackerel, but also pilchard and chub mackerel. These regulations are different for the coastal purse seine fishery and for the trawl fishery on fishing grounds directly adjacent to the coastal zone.

As mentioned above, the allowable mesh size in purse seines used off the Namibian coast is 11 mm; for trawls used on international grounds it is 60 mm, while certain species such as horse mackerel are caught by both gears. The scientific bodies of ICSEAF have repeatedly pointed out that this situation is very dangerous (ICSEAF, 1985a; 1984b); this may also been seen from material presented in previous sections.

As the stocks are distributed both inside the coastal zone and in international waters, management measures should be coordinated by the parties concerned.

On the Namibian coast the abundant catch of juvenile horse mackerel observed in recent years, and of pilchard earlier, has had a decidedly negative impact not only on the stocks of these species but also on the economic effectiveness of fleets operating on international fishing grounds, and possibly on the purse seine fishery itself.

A similar situation exists in the chub mackerel stock inhabiting the greater part of the ICSEAF Area; its juveniles age 0 and 1 are caught in Division 1.6 by purse seiners with a mesh size of 12.7 mm (though this catch in recent years has been negligible). It should be stressed that there is no information that juvenile chub mackerel occur elsewhere outside Division 1.6.

The management strategy of fixing a constant catch limit for several pelagic species is not the best guarantee that the stocks will not be depleted (Newman et al., 1978). At present, in the case of natural disappearance of certain populations from the fishing grounds (for instance, anchovy off the Namibian coast), fishing effort is shifted automatically to juvenile horse mackerel. Meanwhile, the stocks of horse mackerel, pilchard, anchovy and chub mackerel require, in each case, the use of a different exploitation pattern and mesh size.

It appears that recent fishery regulatory measures in the EEZs of the Republic of South Africa (200 miles) and of the Namibian closed area (13.5 miles) concerning individual catch quotas, fishing effort (licensing system), closed seasons and fishing grounds are quite elaborate for pilchard and anchovy, reducing to a large extent the imperfections and drawbacks mentioned above.

The tendency observed recently to treat the pilchard and anchovy stocks in a flexible way should be encouraged (Le Clus, 1984; ICSEAF, 1984a; South African Fishing Industry, 1985), for example by adjusting the level of fishing effort, or individual catch quota established earlier, to the current stage of progress (or decline) of the population and size of the biomass (Garcia, 1984, after MacCall, 1980). Unfortunately these endeavours do not concern other species of great commercial value such as horse mackerel or chub mackerel. Management measures have not yet been established for these species within the waters of the Republic of South Africa and Namibia.

Fishery regulatory measures in Angola and Mozambique are not sufficiently known for their merits and drawbacks to be discussed.

3.4 Further investigations

An extensive research programme for the first few years of activity of ICSEAF was determined in detail by Newman (1977). Most of these projects have either been completed or are still being carried out; however, quite a few of them need to be continued.

To avoid the repetition of the programme presented by Newman, only the more important projects to be started or continued are briefly mentioned below:

(i) Continuation of basic investigations of the biology and ecology of the major species with special emphasis on the influence of environmental factors and inter-species relationships. It is necessary to continue investigations of stock separation and the determination of biological parameters of the stocks, essential for correct stock assessment. This applies to age and growth rate, age of first sexual maturity, age of recruitment and the dependence between age, weight, and sex, as well as to total natural mortality estimated necessary, by age group to terminal fishing mortality, exploitation pattern, catchability coefficient and others. It is also necessary to verify the numerous but divergent values of parameters established so far.

(ii) The resumption of investigations of the selectivity of the gear used now, especially of various types of purse seines and trawls, with special attention paid to the real influence of the topside chafers used on the length composition of fish caught. In the case of hake and horse mackerel, these investigations should centre on the different masking effect on the selectivity by both young and older fish concentrations. These investigations, together with the results of observations mentioned in (i) above should form a basis for the determination of the optimum age of first capture and the optimum mesh size for the major species and also determine the direct and future effects of their usage.

(iii) The initiation of long-term investigations of conditions influencing natural changes in population abundance and their cycles, especially factors accompanying the phenomenon of population eruption. These would also include the influence of fishing mortality and the determination of optimum exploitation methods, and the programming of correct regulatory measures. These measures should be aimed not only at maintaining the population of the most sought after fish at the possibly constant level, but also stimulate its development as well as limit the possibilities of the development of undesirable species. When this refers to species exploited with the help of different exploitation patterns, these measures should be negotiated and introduced by the parties (countries) interested.

(iv) The continuation of methodological investigations dealing mainly with the methods of stock assessment, i.e., analytical and dynamic production models, which should allow for the prognosis of the allowable exploitation level in the future. It would be desirable to give up the more sophisticated models, demanding, on the one hand, the use of too complicated computer programmes and, on the other, a great number of assumptions which - because of the absence of empirical data - are usually subjective and difficult to check. The initial data for the models should be carefully verified prior to their application for usefulness and reliability, with the specific character of the fishery of each country taken into account. It is also necessary to improve and unify sampling methods and biological information processing methods.

(v) Although the amount of bio-statistical data seems sufficient, and sometimes even too abundant, their quality is sometimes questionable. It is imperative to improve information on the catch and the corresponding fishing effort. The data on effort supplied so far on a monthly basis (STATLANT 47B) do not take into account the proportion in which this effort was expended on each species. Although the monthly basis should be maintained, the data on effort for a given target species should be based on an analysis of each day fished of a vessel from the given tonnage group. From the point of view of stock assessment, not all the data from vessels of a given fleet have to be analysed; a representative sample should be sufficient. The information on length and age composition of catches is also quite large and corresponds to the standard established by ICSEAF (200 fish measured and 20 aged for each 1 000 tons of catch). However, this information is not uniformly distributed over individual fishing seasons; in some months there is too much information, in others it is lacking. In the future, the individual system of data collection could be coordinated among the countries using the vessels of the same tonnage group and the same gear.

(vi) Especially valuable information comes from observations made by scientific expeditions on research vessels. Planned for at least three-year periods, expeditions carry out simultaneously investigations of the environment and fish stocks, enabling the verification of the results obtained from analyses based on the data from catches, especially as regards recruitment and biomass. Research expeditions are also necessary when investigating new objects of exploitation (e.g., oceanic squid or fish from sound scattering layers). The negative side to the expeditions presently organized in the ICSEAF Area is the sporadic nature caused by high costs. Besides, each country organizing the expedition uses different range and techniques of sample collection and data processing, depending on the class and tonnage group of the research vessel. This makes it impossible to compare the results and reduces the value of material collected and observations made in a single expedition. The co-ordination of research expeditions initiated recently by ICSEAF has not brought the expected results, mainly due to the lack of simultaneous coordination in the organizing and financing of the expeditions by states wishing to participate in such ventures.

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